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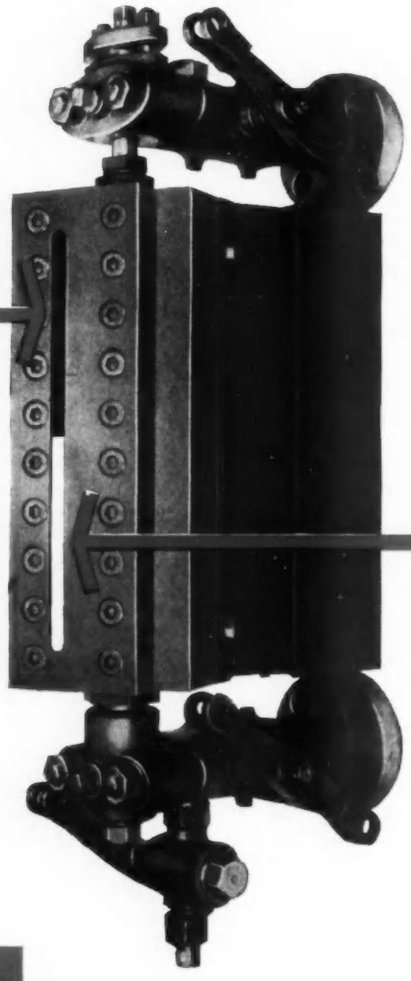

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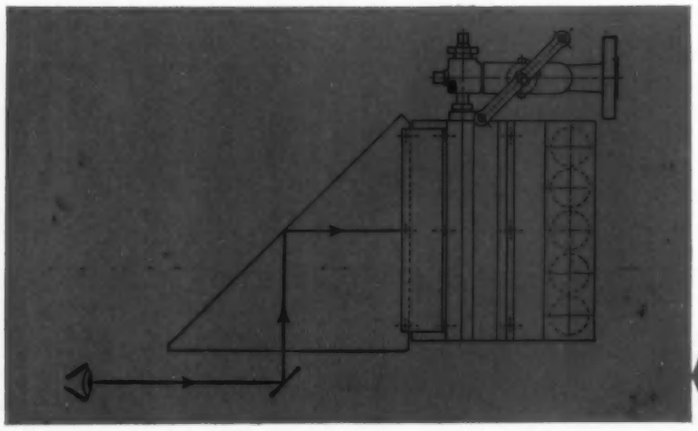
These gauges, which operate on the principle of variable refraction, have been designed for easy handling and long life.



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THE ENGINEER

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No. 5489 **APRIL 7, 1961** VOL. 211

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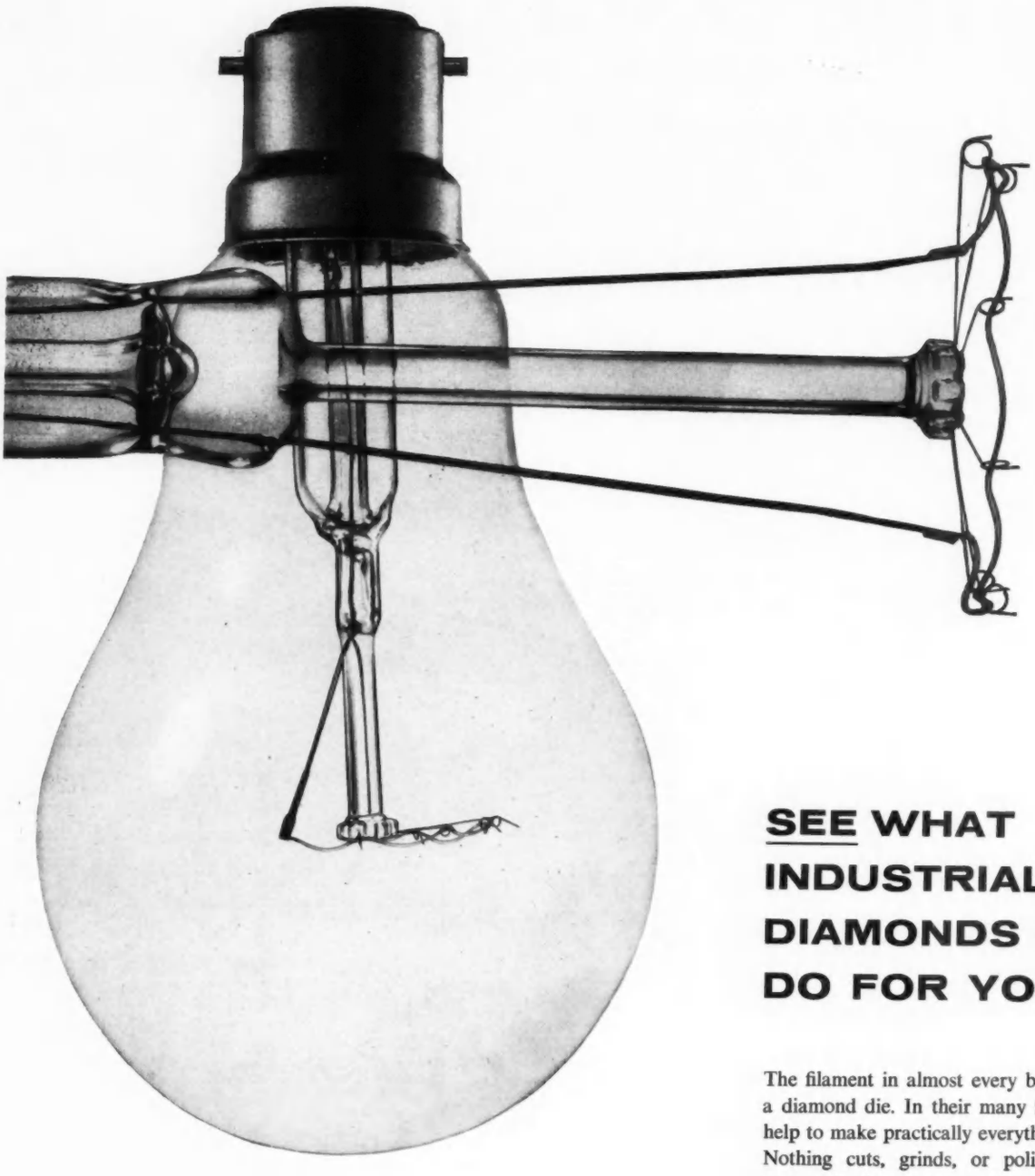

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THE ENGINEER

No. 5489 APRIL 7, 1961 Vol. 211

TEACHING BY TELEVISION

Shortages in the teaching profession are by no means new. It was lack of facilities for local instruction in the thirteenth century which, in the words of J. R. Green, "crowded the roads with hundreds of scholars hurrying to the chosen seats where teachers gathered together." Over the centuries, enthusiasm for education among its principal targets has been restrained in the lower age groups and variable in the higher, but above these levels the impression has persisted that it is something to be desired, particularly among parents, examiners and employers. The problem in these days is to spread the available resources of high-quality instruction as widely as possible. One method of doing so is by closed circuit television, which has been supplied already in the United States and is now on trial in this country. The British experiment has begun in Middlesex, where a demonstration 2-mile microwave system has been provided by High Definition Television, Ltd., between Hayes Grammar School and Barnhill Secondary Modern School for the transmission of science lessons from the grammar schools. Two industrial television cameras are installed in the science class room, one covering the master's desk and the blackboard, and the other available for enlarging small objects and close-ups of experiments. A telephone curcuit provides for questions and answers between the schools, questions being picked up from the front of the class room by training a microphone fitted with a 2ft parabolic dish upon any student bold or rash enough to claim this attention. It should be added that a master is present at the receiving end to exercise the traditional disciplinary functions of his calling by the accepted means. The knowledge that there is a monitor screen in the headmaster's study may be expected to keep the lecturer on his toes, and to invalidate for all time that familiar scholastic excuse, "we've never been told."

A distinction is to be drawn between direct teaching of this kind and broadcasts for schools as known in this country so far. This is emphasised in a booklet, " Educational Television," which has reached us,* and which shows that the value of experiments such as that in Middlesex should not be judged on a basis of experience of educational broadcasting which is designed to provide background material, not the course itself. The usual school broadcast affords the sense of actuality to which, although in a more primitive manner, the pupils of Mr. Squeers were introduced on being sent to clean the "winders" after learning how to spell them. "Educational Television" looks beyond the use of microwave links betwen schools and colleges to an allocation of channels in Band 3 for sixth form courses and adult education organised by the universities. However, the prior importance of closed circuit schemes is stressed, since it is estimated that the present annual output of first-class graduates in all engineering subjects is about equal to the requirement for lecturers in that field. The projected scheme also covers training facilities in the new technique for lecturers, and the possibility is seen of dividing the teaching profession into the grades of class minders, class teachers and studio teachers, the latter paid at headmaster rates but relieved of the headmaster's administrative ties so that they may devote themselves to instruction.

It may be thought that the allocation of frequencies will be the most serious obstacle to putting some of these plans into practice. A factor already in their favour is the growing number of television cameras becoming available for industrial and commercial use in which small size, less weight and simplicity have been specially studied. Some of them will work into a normal domestic television receiver over a length of coaxial cable similar to an aerial lead, and can take power from any mains socket without intermediate control gear. As to frequencies, the position may change with the future development of long-distance waveguide systems. Education should be alert to stake its claim for a share in the additional channels which might be made available by this method of transmission.

ARITHMETICS OF ABSENCE

Everyone appreciates that absences of employees from work may cost industry a quite substantial sum each year. In a booklet just issued by the British Institute of Management estimates are attempted. A survey of absenteeism has been made with the assistance of a number of firms. On average, it has been established, more than a million people are absent from work in Great Britain every day. That is a figure which represents about 5 per cent of the labour force. As the total output of the economy is known, it is calculable that the lost output may be worth as much as £1000 million each year. But there needs to be a note of doubt, because it is not certain that were the absentees at work output would in fact rise by 5 per cent. If the absentee belongs, for example, to a team the remaining members may work a little harder during his absence so as to maintain an unchanged output. Again, in all organisations, it is unlikely that the number of employees will exactly match the amount of work to be done each day. A slight excess of staff may be deliberately maintained so as to ensure that output does not suffer owing to sickness, holidays and the like. But, of course, for other kinds of work the absence of a single man necessarily means the loss of that man's output, neither more nor less; and there are even some kinds of work in which the absence of one man will restrict the output of several more. Thus the figure of £1000 million for the worth of the lost output (or the cost to industry) must be accepted with a good deal of reserve.

But there can, of course, be little doubt that absenteeism does cost firms money. How much, depends on a variety of factors varying from firm to firm; and the booklet recommends a method of costing absence. It should prove

* " Educational Television," by John Wellings, John Wellens (ITT), Ltd., The Sun House, Guilsborough, near Northampton, price 5s. post free.

well worth while for firms to estimate how much the figure is; for there are at least three alternative ways of making up for the lost output. One of them is to work a modicum of overtime; another is to employ extra labour; and a third is to re-deploy some of the labour to make up for absentees. The cost of absenteeism can average out at well over £2 per employee per month; it may be less than 3s. per month. The cost depends partly on the nature of the work and partly on the way in which the work is organised. The comment is made in the booklet "It would therefore appear advisable even for firms with low absence rates to examine their absence costs. It is possible that a change in . . . policy . . . may enable the company to reduce absence costs even though the level of absence itself remains constant." There are, too, imponderable effects of absenteeism which must be harmful. "The problems created by absenteeism may occupy the time of supervisors and department managers to the detriment of other work. The effect on the morale of employees as a whole . . . cannot be good . . . If absenteeism is ignored by the management it will tend to increase."

What can be done to reduce absenteeism? Here a distinction must be drawn between absence due to sickness and accidents and absence for other reasons. Much can be done, of course, to reduce accidents — whole books have been written on that subject. Almost all large firms have found it well worth while to create their own medical departments and many smaller ones are equipped to give simple medical treatments. Some firms have found it worth while for visits to be made to employees absent from work for unknown reasons. They may reveal, for example, the existence of domestic troubles about which advice can be offered or assistance be given. But there always remains something of the order of one per cent of absence, including some which is ostensibly sickness, for which no other reason can be assigned than that the employee felt like taking the day off. What can be done about it? Here we feel less than sure that the booklet follows a sound line. "The company must make clear to its employees where it stands on the question of absence. It must stress that employees have an obligation to come to work unless they are sick or prevented by some other compelling reason. . . . Absence which is not due to sickness, and has been taken without permission, should be checked on when the employee returns. In some cases the most appropriate action may be a sympathetic discussion of his difficulties; in others disciplinary action . . ." Those words do not seem wholly in tune with the advanced ideas of management which are becoming current. In a talk given by Mr. Coutts Donald, chairman of the Management Consultants Association, at a recent three-week conference of European Management Consultants there were spoken the words "In the days of primitive management the idea was to get work done through fear. Managers got people to work by threatening them with their discharge. Then we had the second phase which was paying employees according to what they produced. . . . The interest of management is now focused on a third method of getting work done. That is, removing obstacles which prevent workers doing their job . . . based on the belief . . . that all employees want to make good in their jobs . . . and that it is the task of the manager to help. . . ." If a similar line is followed when thinking about absenteeism the conclusion may be reached that occasional absence from work by an employee may be much less costly than it appears to be. A jaded employee who takes a day off may come back refreshed, better-tempered, less likely to fall sick or suffer an accident and better able to maintain a high rate of output. Far from lowering the rate of output of the factory the ultimate result may be to raise it. The accountant's reckoning makes no allowance for such factors. What is the truth?

THE PURPOSE OF CRITICISM

The quick answer to the query "What is the purpose of criticism" is, of course "To correct error." It is too quick; though we fear some critics never come to appreciate the point. For there is an offensive arrogance about it; a god-like air of "I know best." Moreover, except in such simple matters as mathematical calculation, historical sequence, departures from the rigidities of dictionary spelling and incorrect reporting of factual knowledge, about which there can be no argument, it is almost never possible to prove anybody wrong. For in most matters about which there can be any argument people are very seldom right or wrong; they are only more nearly or less nearly right, according to one's point of view. It is therefore unwise for a critic to pretend to more knowledge or better knowledge than an author possesses. Some of the savage things the critics had to say about Shaw's plays when they were first performed, for example, sound pretty silly to-day! The answer "To correct error" needs therefore to be modified. It might, of course, become "To point out the probability of error." That is certainly an improvement; but the aura of arrogance still hangs around it. The critic, it suggests, has so much the greater perspicacity than the author that he can see a probability of error hidden from the author. No wonder writers, artists, and designers detest and deride their critics; for this is often precisely the attitude critics adopt.

How then should one define the purposes of criticism? We suggest that in fact the smelling out of error is a small and relatively unimportant part of criticism. A critic should be humbly aware that he is unlikely to be wiser than the author or designer whose work he is commenting upon; and that he is writing or talking about people who lay claim to at least a little of that creative quality without which no advance can be made. Except, therefore, where rank carelessness can be perceived or, worse, there seems to be a deliberate attempt at deception, the purpose of a technical critic should surely be not to pretend to any greater percipience than the one criticised, but to draw attention to other ways of studying a problem — leading to some different, though not necessarily better, solutions; to confess, in need, to inability to follow his expositions, with the implication that he could with advantage have made them simpler to follow; to compare his work with that of others, though preferably to neither's disadvantage and rather to show up differences in approach; in fact to discuss rather than to criticise, to draw out an author or designer, and to encourage him in the advancement of knowledge and the improvement of taste.

All men we suppose number sadism amongst the emotions they can experience. Under the irritation of seeing, hearing, or reading something offensive to preconceived ideas or what we believe to be fact it is all too easy to pick up a pen and dash off a criticism which scarifies the author, composer or designer, accompanied by the wounding implication that if he is not such a fool as to be unable to see his own errors, he must be a knave having some deep and no doubt immoral purpose in propounding them! Immense satisfaction is to

gained from thus letting off steam. For our part we never deny ourselves the satisfaction of doing so. We hasten to add that we do not publish the result! For in the technical world and particularly amongst engineers we feel it surely to be the duty of a critic to attempt to understand and sympathise with those whose work he is called upon to criticise. Pen in hand behind a writing desk it is only too easy to overlook that an author or a designer is human. It is quite otherwise when one is face to face with him. Correspondence in technical as in other kinds of journals quite often becomes acrid—or, at least, as acrid as the Editor will permit — probably because the antagonists never meet. By contrast how seldom at an Institution meeting is an author savaged! Even when he has little to say that has not been said before, says it at length and without clarity and mounts improbable conclusions on uncertain premises it is only delicately, politely, and slowly that his critics, as much by asking awkward and unanswerable questions as by direct assertion of error, remove one by one the props and stanchions to bring the whole unwieldy edifice crashing about his ears. But hostility is not aroused. Indeed, it may be that what is apparent to the audience may be imperfectly perceived by the author. But whatever his degree of enlightenment, as likely as not he will happily go out to dinner with his critics!

ON BEING "TAKEN OVER"

The recent publication of the twelfth report on the operation of the Monopolies and Restrictive Practices Acts, 1948 and 1953, coupled with the almost daily news of fresh "take-over" bids and counter bids for firms involved in everything from publishing to property and from brewing to building, must cause everyone seriously to think. Presumably the organisations involved in these link-ups hope to acquire financial and industrial power by reason of their enhanced size. No doubt those at the top hope to be able to "streamline" production in some way as the businesses so linked are often of similar character. Usually, it seems, the shareholders in the companies concerned have the satisfaction of finding the value of their shares appreciate. But the customer appears to be ignored at first, to be wooed later with added fervour once take-over is complete. Often he is then offered a more restricted range of wares. And what of the employee? The National Institute of Industrial Psychology stated in its annual report that it has been studying the attitudes of employees to having their company taken over by another and that it will issue a report on this subject in the near future. We look forward to reading the report. But in one respect such a survey is hardly necessary. An immediate reaction of an employee who learns that his firm is involved in a "take-over" battle, is that his position must immediately be regarded as insecure. The companies, once married, are likely to find, for example, that each has a transport manager but that one would now do. The office boys of both firms (if anything ever worries an office boy) are likely to worry just as much as the managers which one of them will become redundant when the financial "tumult and the shouting dies."

We are reminded of a speech made by Mr. Peter Runge, managing director of Tate and Lyle, Ltd., when he addressed the annual conference for apprentices held by the Industrial Welfare Society at Oxford last September, in which he commented on a growing tendency during the past century for people to join together to form large groups. The more serious manifestation of the same tendency, he went on to say, was the growth of individual factory units into "citadels of concentrated toil." There was no doubt at all, he added, that large factory units were not normally such happy places as those employing smaller numbers. They might be more efficient, but they were far less human. There were, Mr. Runge continued, thousands of "scruffy little factories" where ten men worked together far more happily than if they were all herded together in a "slap-up" place with all modern conveniencies attached. It was a problem, Mr. Runge said, which was receiving a lot of attention, but the attention was being directed towards developing techniques of management which would reproduce in large places the happy atmosphere of the smaller unit. Mr. Runge went on to say that he would rather see the attention directed towards the small unit, for he believed it to be an impossible task to make the "card index and works handbook" do the job of the personal contact and word-of-mouth instruction. If Mr. Runge is right we must conclude that "take-overs" are bad for industrial relations. But we cannot think they necessarily are. We can think of a number of very large concerns which seem to have found the secret of maintaining excellent relations with their employees who, indeed, take great pride in belonging to and serving those concerns. We can think of others where relations seem congenitally bad and squabbling is incessant. But what is certain is that when a small firm is taken over by a large one none of those employed can know what the future will bring. The apparent security of the past is shattered. Whilst the more adventurous may see in an amalgamation a chance of increased scope for individual talent, there are many more whose peace of mind will be seriously disturbed by the swallowing-up of the smaller unit. Only, perhaps several years later, when re-organisation is complete will they be able to recover it — not perhaps wholly a bad thing.

The Engineer—100 Years Ago (APRIL 5, 1861)

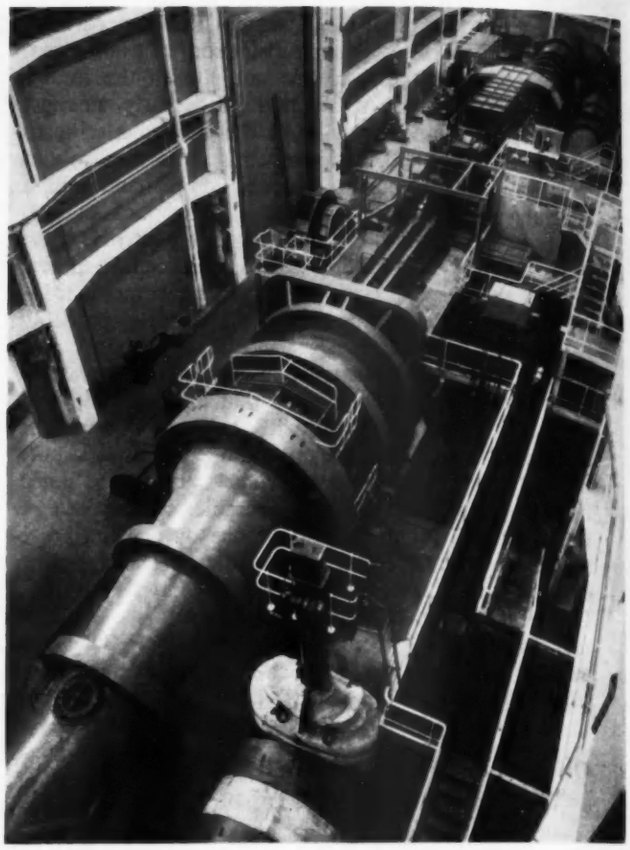
"SOCIETY OF ARTS EXHIBITION"

"Many useful machines are represented . . . by models. . . . There are, however, full-sized washing machines, cooking ranges, mantles, printers' cases, &c., whilst there is also a cylinder printing machine, that of Mr. Davies, of York Villas, Sydenham Park, about the size of a pocket prayer book, and said to be the smallest in the world, yet capable of printing ten thousand impressions per hour!

"Perhaps the most interesting object in the whole exhibition is Mr. Shaw's ingenious 'Thaumotrope', or apparatus in which, in addition to the solidity of the stereoscopic object, apparent motion is exhibited. A series of stereoscopic slides, all representing the same object, but in gradually varying positions, are arranged on the flat sides of an octagonal drum. This is rapidly revolved, on a central axis, at right-angles to the line of vision, and is at the same time viewed through the stereoscope, the view, however, being successively interrupted by the exclusion of the light between the passages of each pair of slides before the eye. The effect is remarkable, especially when a steam engine, photographed on a succession of slides at successive parts of the stroke, is placed before the eye. The illusion is hardly so perfect however, as to remove the consciousness that a succession of similar objects is passing before the eye."

High Supersonic Wind Tunnel

The 3ft by 4ft wind tunnel at R.A.E., Bedford, has now commenced operation with a fixed Mach 4 nozzle ; it will eventually have a continuously-variable nozzle, anchored to a "bridle" at the working section where the workmen are seen in the picture here. The numerous corners in the circuit render the tunnel suitable for use with flexible flutter models.

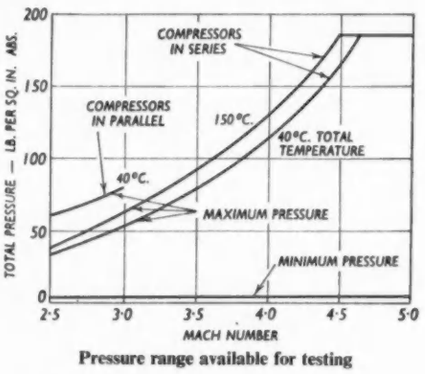


LAST Friday week the Minister of Aviation, the Rt. Hon. Peter Thorneycroft, M.P., opened the " High Supersonic Speed Wind Tunnel " at the Royal Aircraft Establishment, Bedford. The design of this tunnel was commenced in 1955, and both in concept and in power and mass flow it resembles the 8ft by 8ft tunnel on the same site ; the section of the new tunnel is 4ft high by 3ft wide, and it is interesting to note that the reduction in volume allowed far more use to be made of normal techniques and devices than in the larger tunnel, for which the design case was the filling of the ducting with water for pressure testing. The new tunnel has a circuit with a large number of corners, and consequently it is considered safe to use it with flexible models that may break up under test ; it is also considered possible to tolerate a limited amount of combustion in the working section, if necessary for realistic testing of propulsion systems. Although the tunnel is intended to encompass the Mach number range of 2·5 to 5—the variable nozzle was illustrated in our original description of the facility on page 95, July 19, 1957—it has at present a wooden nozzle which sets a limit of 40 deg. Cent. on the stagnation temperature ; even in its present state it is capable of reproducing on a quarter-scale model free flight Reynolds numbers of a 20ft long body at 60,000ft or above.

Inlet total pressures up to about 12 atmospheres are needed for high Reynolds numbers, and air temperatures up to 150 deg. Cent. to avoid liquefaction effects at the upper end of the speed range.

It was estimated that the starting conditions of this tunnel would require a compressor plant having a range from around 350,000 cubic feet per minute volume flow at an overall pressure ratio of about 20 : 1 at the M=5 condition to around 470,000 cubic feet per minute at 2·7:1 pressure ratio at the M=2·5 condition. Since, with the adjustable nozzle, it was not essential to be able to start the tunnel at the Mach 5 condition a maximum pressure ratio of rather less than 20 : 1 could be accepted.

There appeared to be a good chance that compressors of sizes already developed for industrial purposes could be used in suitable combinations to match the range of starting and running conditions required by the tunnel. It was confirmed that more than one manufacturer could match the tunnel requirements by using two sets of compressors running at 3000 r.p.m. in parallel, the two compressors comprising each set being operated in series to give the high pressure ratio and lower volume flow for the upper end of the tunnel speed range,



Pressure range available for testing

or in parallel to give the high volume flow and lower pressure ratio required at the lower end of the speed range.

With compressors running at 3000 r.p.m. the choice of a direct drive from a two-pole synchronous motor built into a 30MW turbo alternator frame was almost automatic. For starting purposes a six-pole wound rotor induction motor drives each 3000 r.p.m. shaft through speed increasing gears of ratio 931·6 : 3000. These motors also contribute their full share of power to the compressors during normal running, the loading being controlled by the water-cooled liquid controllers which are also used for starting.

The total power input available to the compressors has been limited to 88,000 b.h.p. to match the demand of the 8ft by 8ft High Speed Tunnel. This power is just sufficient to provide for total inlet pressures to the tunnel of about 12 atmospheres at maximum speed condition. The total power of 44,000 b.h.p. per compressor set is provided by a synchronous motor of 34,000 b.h.p. and an induction motor of 10,000 b.h.p. The latter can drive the set up to synchronous speed when the static pressure has been reduced to less than one-third of atmospheric pressure.

The power supply arrangements are such that the plant can be operated either from C.E.G.B. supply or from the R.A.E. Bedford 40MW gas turbine driven generating station at a frequency of 50 c/s. The plant has also been designed so that it can be run from the latter source of supply at lower frequencies than 50 c/s for better matching of the compressor and tunnel characteristics, but in this case only the synchronous motors are supplied at reduced frequency.

This particular arrangement of the compressors and driving motors involves a long shaft system of reduced natural frequency in torsion. The use of a wound rotor induction motor in association with this shaft system introduces the possible hazard that torque pulsations originating in the motor may, under certain conditions, build up torsional vibrations in the shaft system to a dangerous amplitude. It was known that a small unbalance of the currents in the three-phase windings of the induction motor rotor could give rise to torque variations at twice slip frequency. Precautions taken to reduce torque variations to a minimum and to prevent coincidence of the exciting frequency with the natural frequencies of the shaft system are described later.

The tunnel performance required demands maintenance of the humidity of the air in the circuit at a very low value, a dewpoint below −50 deg. Fah. or a moisture content of less than 0·00005 lb of water per lb of air being the target.

The method adopted to achieve and maintain this low moisture content involves purging moisture already in the circuit by cycles of evacuation followed by recharging with dry air and packing all glands, seals and joints in the circuit with dry air at a pressure just above atmospheric to preclude inward leakage of moist air.

For this purpose air is dried to reduce the moisture content to less than 0·00002 lb per lb (dewpoint below −70 deg. Fah.) by compression to 4500 lb per square inch followed by aftercooling with brine to 40 deg. Fah.

Dry air is stored at a pressure of 4500 lb per square inch in sufficient quantity to permit rapid purging of any moisture in the air in the circuit. One advantage of this arrangement is that the time required to achieve the desired dewpoint in the circuit becomes a function of only the capacity of the evacuator plant. With a powerful evacuator plant, capable of evacuating the circuit to an absolute pressure of one-tenth of an atmosphere in four minutes, the moisture initially in the circuit can be removed in about twenty minutes. Thus loss of operating time after opening the circuit to the atmosphere is reduced to a minimum.

The maximum rate at which the pressure level in the circuit can be increased by admission of dry air from storage when the compressors are running is governed only by the permissible rate of increase in demand for electric power, which is limited to 10MW per minute.

The large dry air storage has immediate and potential uses other than purging of moisture, sealing of glands and control of pressure level in the circuit. It can also be used for injection of dry air at a high rate upstream of the nozzle to give a momentary boost to the pressure ratio across the nozzle when required to establish supersonic flow under conditions where the pressure ratio of the compressors may be marginal to the requirements. The large quantity of air stored at 4500 lb per square inch also has potential use for driving hypersonic intermittent tunnels.

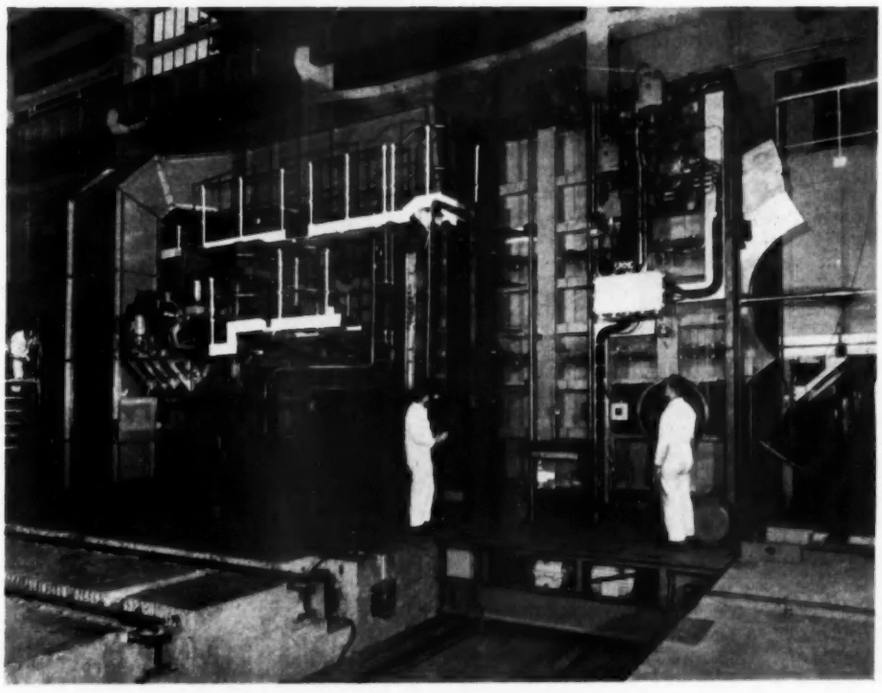
The temperature of the air delivered by the main compressors to the nozzle and working section can be varied between the limits of 40 deg. Cent. and 150 deg. Cent. at a rate of change of approximately 20 deg. Cent. per minute by allowing an increasing proportion of the air delivered by the compressors to by-pass the after-coolers.

High working temperatures and high rates of change of temperature of the air in the tunnel circuit, combined with the high degree of precision required in the devices which will measure and control the throat and contour of the nozzle, were considered to preclude the enclosure of the complete nozzle and its controlling devices within a pressure shell as in the case of the 8ft by 8ft High Speed Tunnel.

With the sensing and positioning devices in the open outside the tunnel circuit many difficulties were avoided but, this being a continuous as opposed to an intermittent tunnel, the particularly difficult problem of providing a very efficient sliding seal between the moving and fixed walls of the nozzle was introduced.

This sliding seal is required to preclude completely inward leakage of air from the surrounding atmosphere when the circuit is at sub-atmospheric pressure and to limit outward leakage under a pressure differential of 12 atmospheres upstream of the throat to a small amount. The former requirement postulates a double seal with dry air packing, the latter requirement demands high mechanical pressures between the seal and the fixed surfaces on which it has to slide, bringing in its train problems due to frictional drag, deformation and stick-slip effects. The high and variable temperature introduces problems due to thermal variations in the gap to be sealed necessitating a considerable amount of follow up by the seal. It also involves the development of materials for the seal having at high temperature the necessary properties of resiliency, low compression set and low coefficient of sliding friction.

The solution of these and other problems posed by the adjustable nozzle and the development and proving of satisfactory designs was foreseen as being likely to take longer to complete than other features of the project. It was therefore decided to provide a nozzle of fixed contour for Mach number 4 so that useful work could proceed while development and testing of the moving wall nozzle was completed outside the tunnel circuit. The fixed nozzle is now in use in the circuit and the components of the moving wall nozzle are in process of being assembled for testing alongside.



Supersonic diffuser retracted and model support section disengaged for removal from the circuit on the traversing trolley. Notice the ducting from the blow-off valve protecting the working section and diffuser which mates with the section protruding from the floor

Tunnel Air Circuit

The tunnel air circuit comprises the working section leg, the compressors, the coolers and a system of pipework and valves necessary to complete the closed circuit and to permit the compressors of each set to be operated either in series or parallel according to the characteristics required.

A 60in diameter by-pass line, controlled by a full bore, fast acting valve of the rotating plug type and by a smaller gate valve for fine control, is connected in parallel with the working section leg. This by-pass line has four major purposes. Firstly, it permits matching of the compressor plant characteristics to the tunnel requirements at the upper end of the speed range. Secondly, it permits the compressor plant to be kept in operation while the working section leg is isolated and opened up for access to the model, thus greatly reducing the loss of operating time caused by this operation. Thirdly, it permits the compressor plant to be run up to speed without establishing supersonic flow in the working section leg : rapid closing of the 60in by-pass valve then results in the establishment of supersonic flow in the shortest possible time, the shock wave front being driven rapidly downstream past the model with the minimum risk to it. Fourthly, the existence of the by-pass incorporating a venturi meter throat permitted the testing and evaluation of the compressor characteristics while the working section leg was still under construction.

Another by-pass line with control valve is provided in parallel with each aftercooler so that the temperature of the air delivered to the working section leg can be conveniently controlled over the range of 40 deg. Cent. to 150 deg. Cent.

All pipework was fabricated from 26/30 ton boiler quality steel plate, to B.S.S. 14, of ¼in and ⅜in thickness ; the total weight about 730 tons.

More than forty right angle bends are incorporated in the circuit. Each bend is fitted with cascades to reduce turbulence, the design being such that the cascade vanes provide the stiffening required by the elliptical cross section where they are fitted so that external stiffening rings are unnecessary.

The pipework system is anchored or constrained at the connections with the compressors, at one point in the working section leg and at certain other points. In between these points the pipes are supported at the centre line on spherically ended spring loaded struts which allow free movement of the pipework to take up changes in linear dimensions due to temperature changes. Expansion and contraction in the length of the

pipes is accommodated by the use of a combination of externally linked bellows joints each of which permits bending in one plane without releasing heavy thrust loads. This arrangement has eliminated the need for a considerable number of heavy concrete foundations which would otherwise have been required to anchor the pipework between expansion joints.

Subject to limitations imposed by transport arrangements and erection considerations the pipework was prefabricated at works in sections, using machine welding methods to a considerable extent. Design and workmanship were required to conform to Lloyds Rules for Class 2 Welded Pressure Vessels and as an additional continuous check on the quality of welding, 5 per cent of the welds were radiographed. The percentage was increased to 100 per cent in the case of welds on certain of the bellows joints where the 5 per cent check revealed the probability of defects.

Before despatch to site prefabricated sections were shot blasted internally and externally to remove mill scale and rust. External surfaces of pipes to be erected out of doors were sprayed with aluminium. All other surfaces were given temporary protection against rusting.

After erection and completion of site welding the complete l.p., i.p. and h.p. zones of the pipework were hydraulically tested to 30 lb, 140 lb and 360 lb per square inch respectively.

Air swept surfaces subject to temperatures not exceeding 150 deg. Cent. were subsequently stripped of the temporary protective coating and finished with two coats of light grey protective paint. This is found to assist in maintaining the high degree of cleanliness required in the circuit.

Valves used for circuit selection purposes are of the wedge gate type and those used for control purposes are of the full bore rotating conical plug type which permit higher speeds of operation. Valves which may be subject to high pressures and temperatures have fabricated or cast steel bodies. The principal air circuit selection and control valves are hydraulically operated under the control of solenoid-operated pilot valves. Valves used for control purposes are fitted with four pilot valves which give the option of fast or slow operation in each direction.

Non-return valves are fitted at each compressor discharge branch to prevent reversal of flow when one set is running and one set stationary. Pressure relief valves are fitted to limit the pressure level on the inlet and outlet sides of the compressors to the maximum design figure.

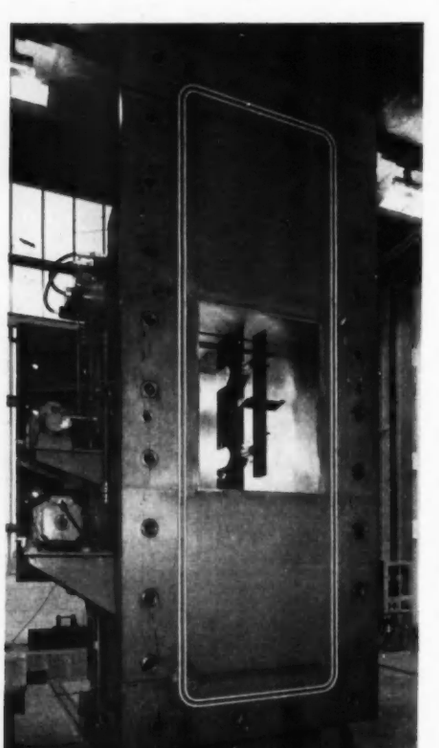
Very high noise levels have been experienced in the compressor and working section bays of the building under operating conditions. The general level measured with the compressors at full power is of the order of 105dB to 110dB but adjacent to the return pipework downstream of the working section a level of 117dB has been measured and in areas adjacent to the 60in main by-pass downstream of the control valve noise levels over 130dB have been recorded with the full flow passing through the by-pass line. Arrangements are being made to reduce these peak levels by selective treatment with sound absorbent constructions but it is evident that the use of ear defenders will continue to be necessary for personnel working in these areas when the plant is in operation.

Working Section Leg

The working section leg of the tunnel circuit is 154ft 6in long between the centre lines of the cascade bends at each end, and comprises an inlet cascade bend, an inlet cone and settling chamber with screens, a contraction section, a nozzle, a model support section, an adjustable supersonic diffuser, an outlet section with subsonic diffuser, catch net, and outlet cascade bends followed by a second catch net.

One of the principal design requirements has been to provide maximum availability of the tunnel for testing work. Since the rigging of a model with its instrumentation may take up a considerable period of time it must be possible for this work to be undertaken outside the tunnel circuit while tests are proceeding on another model. For this reason all arrangements for the mounting, manipulation and instrumentation of models are incorporated in a number of separate and interchangeable model support sections or trucks which can be quickly disconnected and removed bodily from the air circuit to an adjacent rigging bay.

Sections of this leg of the tunnel circuit both upstream and downstream of the nozzle section are arranged to travel on a system of rails accurately levelled and located on a grillage embedded in the concrete foundation. This arrangement provides for axial movement to accommodate expansion upstream and downstream from an anchor point at the downstream end of the nozzle. It also provides facilities for introduction or removal of the screens in the settling chamber and for removal or interchange of model support sections. A transporter truck running on another set of rails at right angles provides for transport of model support sections into and out of the tunnel circuit and for their transfer to any one of four sidings in the adjoining rigging room or to another siding under the crane in the main bay.



The calibration section seen parked beside the tunnel ; notice the dry-air-packed glands on the joint face and the interrupted-thread nuts effecting the joint

The joints between mating flanges on both sides of the model support section and at the junction with the compressor inlet piping at the downstream end, which must be frequently broken for interchange of model support sections, are made by breech-thread quick release bolts operated by hydraulic actuators.

The inlet section comprises a 5ft diameter cascade bend followed by a 10 deg. angle cone some 20ft long increasing to 9ft diameter and a pressure shell 11ft diameter which accommodates the 9ft diameter inner fairing of the settling chamber and the contraction fairing. The settling chamber accommodates up to five screens of 30 mesh 33 S.W.G. stainless steel to reduce turbulence. Access to the screens for removal and cleaning necessitates breaking bolted circumferential flange joints in the 11ft diameter pressure shell and at the upstream end of the inlet bend, following which the complete inlet end can be withdrawn some 9ft upstream by means of a hand-operated chain rack and pinion drive.

The nozzle at present in use in the circuit is of fixed throat gap and wall contour giving a nominal Mach 4. It consists of a pair of wooden, flat, vertical side-walls 3ft apart with a pair of wooden fairings forming the last part of the contraction, the throat and expansion region. The throat size is 3ft wide by 4in high. At its downstream end the nozzle is 3ft wide by 4ft high and this is the test section of the tunnel. Calibration of the tunnel has shown that, at maximum pressure, the Mach number here is 3·98 and that the variations in Mach number over the test region are within $\pm 0{\cdot}02$.

Model illumination is provided by a double ring of cold cathode fluorescent lamps at the outer periphery of the low temperature window. The lamps have an output of 270 lumens per foot run to give an illumination of about 75 lumens per square foot at the model position. On the high temperature window mercury vapour lamps of 125W rating are mounted opposite each of the three 8in diameter ports. Opposite the fourth port, which is 19in in diameter and used for camera viewing, is a single run of cold cathode tube similar to that used with the low temperature window. These arrangements are expected to provide about 100 lumens per square foot at the model position.

A closed circuit, 625-line, high definition T.V. system is provided for model viewing. This incorporates a miniature camera with interchangeable lenses of focal length 0·7in and 2·0in. The camera is mounted within an enclosure through which the Schlieren light beam passes and is arranged for remote control of pan, tilt, traverse in three directions, lens interchange and focusing.

Each of the interchangeable model support sections is mounted on four flanged wheels, one pair of which is driven through a clutch by a 3 b.h.p. induction motor to give a travel speed of 20ft per minute. The wheels run on steel rails along the line of the working section leg, on the transporter carriage, along the sidings in the rigging room, and under the crane in the main bay. Power supply for the motor, which is used to transfer the section between the sidings and the transporter, is provided through a flexible cable mounted on a self-reeling drum at each siding to a plug-and-socket connection on the unit.

When a model support section on its transporter is in line with the working section leg, the downstream section is moved up to it by a hydraulic ram operated device on the supersonic diffuser undercarriage until the flanges of the model support section and of

the supersonic diffuser are brought into contact under the guidance of alignment devices. The model support section is then driven further upstream by the supersonic diffuser until its other flange comes into contact with the downstream flange of the nozzle section, again under the guidance of alignment devices. During the last inch of travel multi-contact plug-and-socket connections are made automatically to complete all electrical circuits for control and instrumentation on the model support section. Finally the flanged joints on each side are locked together by hydraulically-operated quick release bolts. A double silicone rubber seal with dry air packing of the space between the seals is employed at each joint.

The flat walls forming the sides, top and bottom of the 4ft high by 3ft wide internal duct are fabrications from 2¼in thick " Colclad " rolled plate. During machining, flatness errors on the stainless steel airswept surface have been held to less than 0·005in per inch and surface finish to better than 80 micro-inches.

The sting carrier shaft with its drive and supporting bearings is mounted in a moving quadrant of stainless iron weighing about 2½ tons. This is driven by a pinion engaging with teeth cut in the back of the quadrant to give control of pitch angle between the limits of 5 deg. depression and 27 deg. elevation from the horizontal. The driving and servo positioning control will give rates of change of pitch angle up to a maximum of 1 deg. per second with a specified setting accuracy of ±0·05 deg. at any point in the range.

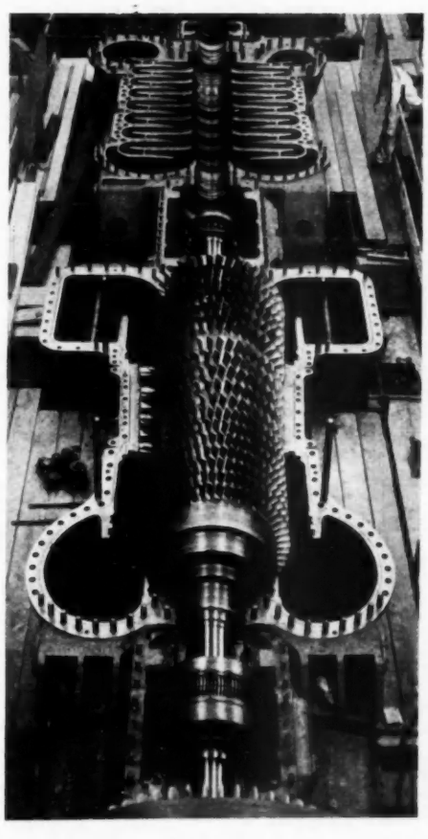
The roll drive, through a gearbox mounted at the rear of the quadrant, can rotate the sting carrier shaft through an angle of ±180 deg. at a speed which can be preselected up to a maximum of 2·5 deg. per second with a specified setting accuracy of ±0·1 deg. at any point.

Rotating shaft position digitisers within the model support section, each driven by a shaft in the gear train in close proximity to the quadrant or sting carrier, provide data for indicating and recording the angle of incidence and roll. These are of a new contactless design developed for this application to overcome difficulties experienced with digitisers of the segmental disc contact type under the high ambient temperature conditions. Each digitiser employs four magslip transmitters geared together in 10/1 chains. Each transmitter energises three mixing transformers the secondary windings of which are interconnected to give five output voltages which vary with the shaft position. When phase-consciously detected these outputs are used to provide two separate output codes to operate a four digit display controlled by four " M "-type motors and a punched card recording and computing system.

There is a calibration section of generally similar construction to, and mechanically interchangeable with, the model support sections. It is designed to provide facilities for exploring the flow pattern in the region in which the model is mounted. In place of the quadrant and sting carrier provided on the model support sections, it is fitted with a probe arm of wedge section and cruciform shape extending some 3ft in a vertical plane which can be traversed some 6ft in an upstream and downstream direction and laterally at right angles to the direction of flow. The probe arm incorporates seven pressure measuring heads. Movement of the probe arm is controlled by positioning servos and data on its position is provided by digitisers both of which are generally similar to those used on the model support sections.

The supersonic diffuser comprises a heavily ribbed pressure shell of rectangular cross section some 31ft long with an internal duct 4ft high by 3ft maximum width between the airswept walls. This is mounted on wheels which run on steel rails. Two hydraulic rams, driving through a rack and pinion device, permit this unit together with the model support and downstream sections to be retraced some 11ft in a downstream direction for interchange of model support sections.

The top and bottom airswept walls of the diffuser are fixed. The vertical airswept side walls are formed by two sets of three vertical plates hinged together. The upstream end of the first plate is arranged to pivot about a hinge pin supported from the outer casing. The downstream or third plate is located from the outer casing by hinged links at each end which permit movement in an upstream and downstream direction but constrain it to remain parallel to the tunnel centre line. The adjacent ends of the 9ft 6in long upstream plate and 11ft 6in long intermediate plate can be moved inwards or outwards to form a second throat by a 6 b.h.p. separately excited direct current motor driving a ballscrew jack through a 50:1 worm reduction gear to give a total travel of 12·6in. The



The eighteen-stage axial and eight-stage centrifugal compressors can be connected either in series or in parallel ; there is a second identical set permanently in parallel with them

motor is controlled by a generator with two field windings and a positioning servo system similar to that used for the nozzle control. At present the second throat gap is controlled by a magslip transmitter on the control desk and its setting is indicated by a digital display. Eventually it will be controlled by a plate cam on the nozzle controller and the setting will vary automatically with the Mach number setting of the nozzle.

Pressure points are provided along the length of the diffuser for remote indication of the shock position.

The subsonic diffuser, some 28ft long, incorporates a square to circular transition section 6ft diameter at the outlet. The first catch net is constructed from ⅜in, 6/19 S.W.G. wire rope with a breaking load of about 0·6 ton. This is interlaced at 2in square mesh and tensioned by springs. The second catch net is intended to intercept fragments of any part of a break-away model which may penetrate the first net and break up on the vanes of the cascade bends. This is constructed with 16 S.W.G. steel piano wire interlaced at about 1in square mesh.

The Main Compressor Sets

Each of the two compressor sets comprises an h.p. compressor, an l.p. compressor, a synchronous motor, speed increasing gears and an induction motor, arranged in the order stated. The two sets are installed in line, with the induction motors at opposite ends of the building and the h.p. compressors adjacent in the middle. This arrangement keeps down the span of the crane and roof trusses and is convenient from the point of view of pipework layout.

The l.p. compressors are axial flow machines of eighteen stages designed to give an overall pressure ratio of 4·35 : 1 with an inlet temperature of 40 deg. Cent. and an inlet volume flow of 208,500 cubic feet per minute at a speed of 3000 r.p.m. Under running conditions the inlet pressure can vary from 22 lb per square inch absolute down to less than 0·5 lb per square inch absolute. In order to keep down loads on models in the tunnel at the instant of starting supersonic flow, a low stagnation pressure is required. At high pressure ratios this necessitates very low pressures on the inlet side of the l.p. compressor and one unforeseen effect of this, discovered during testing, is a sharp and increasing rate of fall in pressure ratio developed by the machines at inlet pressures of approximately 0·6 lb per square inch absolute and below. This puts a limit on the extent to which stagnation pressure can be reduced for starting the flow in the tunnel.

The h.p. compressors are centrifugal machines of eight stages designed to give an overall pressure ratio of 3·7 : 1 with an inlet temperature of 40 deg. Cent. and an inlet volume flow of 49,800 cubic feet per minute at 3000 r.p.m. The 54in diameter impellers are built up from high tensile steel hubs and cover discs with backward-curved vanes secured to the hubs and cover discs by integral rivets.

The inlet ends of each pair of l.p. and h.p. compressors are bolted together and their shafts solidly coupled so that the out of balance thrusts developed in the two machines are in opposition. In the bearing pedestal between the two machines a Michell thrust bearing with surge pads is provided to locate the shaft system and to carry any residual thrust.

A 4 b.h.p. 720 r.p.m. barring motor drives through reduction gears and teeth on the coupling between the compressors to give a shaft speed of 2½ r.p.m. Each compressor gland comprises three packets of labyrinth type seals, and air from the common dry air packing system is fed into the space between the outer and middle packet at a rate sufficient to satisfy inward leakage under the most unfavourable operating conditions and to maintain a pressure just above atmospheric pressure. This precludes inward leakage of moist air when the internal pressures are sub-atmospheric. Tests have shown that under the most unfavourable conditions the

total dry air consumption of the complete compressor plant is in the region of 80 lb to 100 lb per minute. Under most running conditions, where many of the glands are subject to pressure above atmosphere, the consumption is much less.

The compressor plant is designed so that it can be run, if required for better matching of the tunnel characteristics, at reduced speeds corresponding to supply frequencies in the range of 50 c/s to 36 c/s provided by the Establishment's 40MW gas turbine generating plant. The problem of matching the differing characteristics of the axial flow and centrifugal machines at reduced speeds is solved by a servo controlled valve in a by-pass across the l.p. compressors. At speeds below 2700 r.p.m. this valve opens to an extent depending upon shaft speed and effectively prevents surging of the l.p. compressor.

The main driving motor for each compressor set is a synchronous machine of 34,000 b.h.p. continuous maximum rating at unity power factor, 3000 r.p.m. and 11,000 volts. Each motor has a closed circuit cooling system and is capable of developing constant torque on reduced frequency and voltage at speeds down to 2160 r.p.m. In general these machines are of a standard design based on a 30MW turbo-alternator.

The speed-increasing gears through which the six pole induction motors drive the compressor shaft systems are of double helical design incorporating a solid forged pinion and shaft of nickel alloy steel and a gear wheel comprising a cast iron centre on which is shrunk a forged carbon steel rim. The gear wheel shaft is axially located at the outer end bearing and the remaining bearings on the induction motor line permit axial freedom to take up expansion.

The pinion and gear wheel shafts are bored throughout their lengths to accommodate internal shafts of relatively high torsional flexibility. One of these shafts is solidly coupled to the induction motor at one end and to the outer end of the gear wheel shaft at the other. The second shaft is solidly coupled to the synchronous motor at one end and to the outer end of the hollow pinion shaft through a toothed sliding coupling. The latter allows freedom for axial expansion of the high speed shaft line and the axial freedom which the double helical pinion requires.

The reason for adopting this unusual shaft arrangement was to provide a simple method of adjustment of the torsional stiffness in case the resonant frequencies of the shaft system differed from the calculated values.

The coupling between the synchronous motor and the pinion quill shaft is constructed with an insulating barrier to prevent the flow of shaft currents from the motor through the bearings or teeth of the gears.

The induction motors are six-pole wound rotor machines with a continuous maximum rating of 10,600 b.h.p. at full speed. They are supplied at 11,000V and at a constant frequency of 50 c/s. Each motor has a closed circuit cooling system with separate motor driven fan and is capable of developing constant torque at speeds down to 2160 r.p.m. at the compressor shaft.

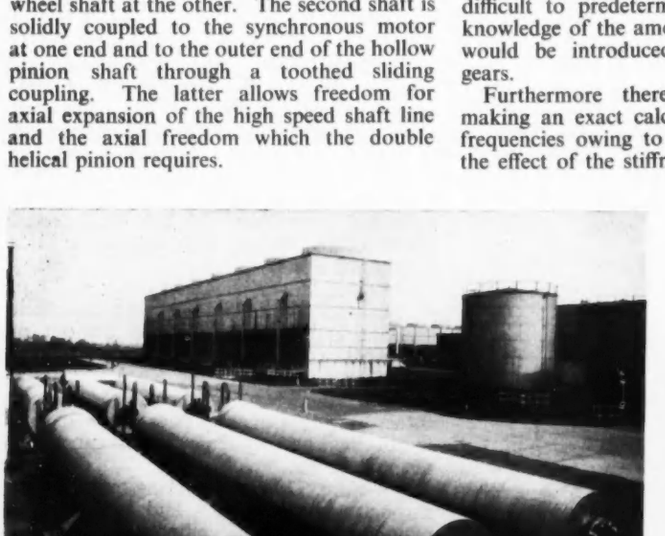
With the tunnel circuit evacuated to a pressure of 5 lb per square inch absolute or below, the induction motors with their liquid controllers bring the sets up to full speed smoothly and without shock to the supply system. After the main motors have been synchronised with their supply the load on the induction motors can be regulated so that they make their full contribution to the driving torque at any compressor speed.

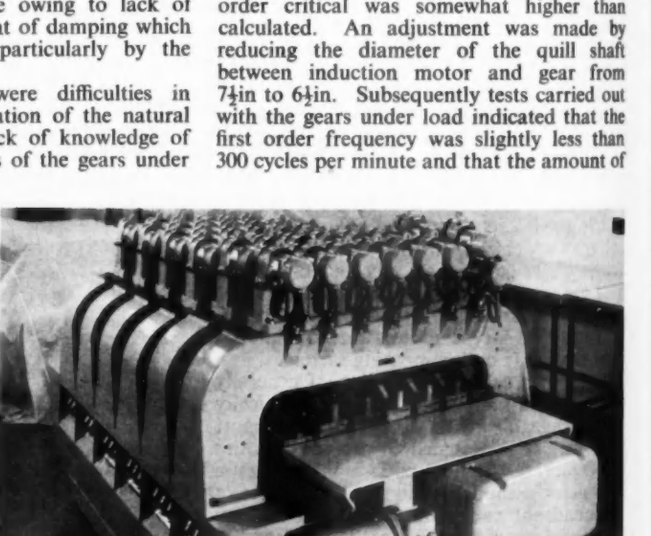
Safeguards against Excitation of Torsional Shaft Vibrations.—One of the problems of the induction motor drive is that any state of unbalance between the currents in the three phase windings of the rotor will cause a cyclic variation in the torque developed of a frequency equal to twice the slip frequency. Normally this is of no serious consequence but in this case the long shaft system has such low natural frequencies in torsion that there was danger of coincidence with the frequency of the torque variations arising in the motor within the range of operating speeds. The risk of the shaft vibrations building up to a dangerous amplitude in the event of coincidence depends on the magnitude of the exciting forces, and therefore on the extent of out of balance between the rotor currents, and also on the damping losses in the shaft system. The latter were difficult to predetermine owing to lack of knowledge of the amount of damping which would be introduced, particularly by the gears.

Furthermore there were difficulties in making an exact calculation of the natural frequencies owing to lack of knowledge of the effect of the stiffness of the gears under load. It appeared that the first natural frequency of the shaft system would be of the order of 300 cycles per minute and that the frequency of the exciting torque from the induction motor would coincide at 5 per cent slip. The first order frequency appeared to be the most dangerous and it was estimated that tooth separation at the gears might occur with out-of-balance currents exceeding 2 per cent of the mean, producing torque variations exceeding 0·8 per cent of the mean torque. Although coincidence of the exciting frequency with the second, third and fourth order criticals at other compressor speeds within the operating range could not be avoided, the estimated torque variation required to produce tooth separation was very much greater and no serious difficulty was anticipated.

The possibility of trouble with the first order critical only arises during run up and synchronisign of the main motor, since at maximum compressor operating speed of 3000 r.p.m. the exciting frequency generated in the induction motor is nearly 40 per cent above the first order frequency of the shaft system. To safeguard the shaft system and gears against this risk during run up and synchronising a protection system has been provided. This has two elements : (i) a device to monitor slip frequency and to operate an alarm if the frequency of the exciting torque falls to within 10 per cent of the first order frequency of the shaft system (5·5 per cent slip) ; and (ii) a device to monitor out-of-balance of the currents in the three phases of the induction motor rotor and to operate an alarm if this exceeds 1½ per cent of the mean current. In the event of both alarms coming up together the induction motor is automatically tripped out. Continuous indication of out of balance currents is provided so that any gradual drift can be observed and remedied before it exceeds a tolerable amount.

On completion of erection, tests were carried out to check the calculated frequencies of the shaft system at barring speeds. These indicated that the frequency of the first order critical was somewhat higher than calculated. An adjustment was made by reducing the diameter of the quill shaft between induction motor and gear from 7¼in to 6¼in. Subsequently tests carried out with the gears under load indicated that the first order frequency was slightly less than 300 cycles per minute and that the amount of





(Left)—The wound storage reservoirs have a working pressure range of 4500 lb per square inch to 700 lb per square inch. In the background is seen the cooling tower (Right)—Controller for the flexible walls of the variable-Mach-number nozzle now under construction ; magslips command the two main eccentric drives to the nozzle beams and the thirty-four pairs of jacks

damping in the system was greater than it had been considered prudent to assume, thus giving a greater margin of safety.

The design of the liquid controllers used in conjunction with the induction motors required special care to maintain the required balance of rotor currents.

Each controller is capable of a continuous dissipation of 3200 h.p. at an electrolyte temperature not exceeding 70 deg. Cent. and a circulation rate of 1200 g.p.m., the total electrolyte capacity being 2000 gallons. Duplicate electrolyte pumps are provided, one acting as standby to the other. The standby pump is brought into operation automatically in the event of failure of the other pump. Heat is transferred from the electrolyte to cooling water in heat exchangers through which cooling tower water is circulated at a maximum rate of 275 g.p.m.

Close temperature control is required to obviate changes of electrolyte resistivity and consequent change of load during normal running. Two sets of controllers are provided. One maintains a constant temperature of about 63 deg. Cent. for normal running conditions. The other comes into operation when the set is stopped and reduces the electrolyte temperature to 52 deg. Cent. in preparation for a restart. In order to prevent the temperature falling below 52 deg. Cent. during short shut down periods, nine thermostatically controlled 9kW heating elements are installed in the electrolyte sump. Circulation of the electrolyte is maintained when the heaters are switched on.

The moving electrode system is precisely guided and is driven by a d.c. geared motor unit with potentiometric control of the armature to give the full travel of 42in from "resistance all in" to "resistance all out" in a period which is adjustable between twenty seconds and two minutes.

Balance of rotor currents within the target figure of 2 per cent can be achieved and maintained without difficulty.

Control and Instrumentation

The control deck is situated between the compressor hall and the working section hall and consists of three rooms and a small laboratory. The Plant Control Room has a direct view into the compressor hall and contains complete controls for all the main and auxiliary plant. The Observation Room has means for controlling completely the tunnel operating conditions once the compressor sets have been run up to speed and also means for observing and recording results from the model area. In addition to the three control desks, instrument racks contain the various analogue recorders for the force and pressure systems and some of their associated digital components. The Data Reduction Room contains gang punches and other items of instrumentation which are not required to be in the Observation Room.

Provision is made for automatic balancing of ten Wheatstone bridge circuits, for plotting the readings against a chosen parameter, e.g. model incidence, and for digitising and recording the results in punched-card form suitable for supplying to a digital computer. A typical channel consists of a strain gauge circuit in which the balancing is completed by the slidewire of a strip chart recorder; this recorder plots the results across a paper chart while the chart itself moves to keep pace with another variable such as model incidence. The shaft rotation of the strip chart recorder is digitised, sorted and read out on demand to the gang summary punch. The punched card output is analysed by feeding into a digital computer.

A total of seventy-two R.A.E. weigh-beam manometers (Midwood manometers) is available for pressure recording. Each manometer automatically balances the pressure in the capsule by moving a jockey weight along a weigh beam and the position of the jockey weight is transmitted to a dial indicator, to a tape indicator and via a digitiser to a gang punch.

Three strip chart recorders are included in the system and each can plot twenty-four pressures on the X axis while the Y axis (the paper roller) moves to correspond to a preset dimension such as the proportion of wing chord at which the particular point is located. Thus a typical plot could be a pressure distribution around a wing profile. The strip-chart plot is an analogue system taking its information from potentiometers on the weigh beam transmitter repeaters.

One particularly elaborate control system is that for the ultimate nozzle, which has thirty-eight variables, i.e. the throat depth, the setting of seventeen pairs of jacks, and the beam pivot adjustment for point of inflection location, on both top and bottom. (See drawing on page 94, July 19, 1957.) The system adopted differs significantly from that of the 8ft by 8ft tunnel which, it may be recalled, had the desired profiles stored on punched paper tape and needed numerous tape readers in duplicate.

The motors controlling the throat gap and the plate jacks are each supplied by a separate variable voltage generator, the output of which is controlled by a positional error signal through a phase conscious amplifier giving a push-pull d.c. output to the two separate field windings.

The input information for each station is set up by means of linear plate cams mounted on the surface table of the nozzle controller. For adjustment of the throat gap and wall contour this table is traversed under a head carrying devices to sense the ordinates of each cam. The sensing devices are magslip transmitters driven through precision cut racks and pinions by the cams. Similarly magslip coincidence transmitters, mounted on unstressed beams above and below the moving walls of the nozzle, sense the position of the throat and flexible plate wall at each station. Any misalignment between the transmitters and the coincidence transmitters produces an error signal of an amplitude which is a measure of the magnitude of the position error and of phase corresponding to the sense of the error. Follow through magslips mounted on a corrector device somewhat similar to the nozzle controller provide for feeding in a number of predetermined or adjustable ordinate corrections for each station if required. Stabilisation of the servos is normally effected by transient velocity feedback, the velocity signal being derived from the armature of the motor driving the output member. All servos on the nozzle can be "frozen" when required by application of solenoid brakes to the driving motor shafts and opening of the servo loops.

The positional setting accuracy aimed at in the design is a throat gap within 0·002in and flexible plate position at each jacking station within 0·001in of the nominal setting. Tests on a prototype jacking station with its servo controls give promise of a close approach to these targets.

At the designed speed of operation the nozzle setting can be changed from Mach 5 to Mach 2·5 in a minimum period of 2·4 minutes. The position of the table of the nozzle controller, which determines the setting, is controlled by another similar positional servo from a magslip transmitter calibrated in terms of Mach number on the control desk in the observation room. The rate of change of setting is adjustable.

Air Coolers

In addition to the normal inter-cooler and aftercooler associated with each compressor set a precooler is required for use at the upper end of the speed range, when the stagnation temperature of the air leaving the working section leg of the circuit may be as high as 150 deg. Cent.

The duty of each precooler is to cool the total inlet volume flow of the l.p. compressor at inlet pressures between 0·5 lb and 14·7 lb per square inch absolute from temperatures as high as 150 deg. Cent. to 40 deg. Cent at inlet to the compressor. For this duty an extended surface water-through-tube type of cooler is used, the air flowing in a single pass across banks of gilled tubes arranged within a fabricated steel pressure shell of rectangular cross section.

The tubes, which are of aluminium brass 1in o.d. and 18 S.W.G. wall thickness, carry an extended air surface of wound strip, 9 turns per inch, in aluminium giving a diameter of 2in over the fins. Pairs of tubes are joined in hair-pin form at the end remote from the tube plate by a brazed-on "U" bend. The rectangular tube plates are of rolled naval brass 1in thick and the tube ends are roller expanded into plain reamed holes.

The intercoolers are generally of similar construction to the precoolers and cool the air delivered by the l.p. compressor from 240 deg. Cent. to 40 deg. Cent. before entry to the h.p. compressor.

The duty of the aftercoolers is to cool the air received from the h.p. compressor at 245 deg. Cent. to 40 deg. Cent. before delivery to the working section of the tunnel. Air by-pass and mixing arrangements provide a quick response method of controlling the temperature of the air delivered to the working section at any desired constant value between 150 deg. Cent. and 40 deg. Cent.

In this case extended surfaces on the air side are not necessary and the aftercoolers are of plain tube design with the high pressure air flowing in a single pass through the tubes and the cooling water flowing outside the tubes in a single cross-baffled pass counter to the air.

The 2001 tubes are solid drawn aluminium brass ¾in o.d. and 18 S.W.G. wall thickness, 26ft long, roller expanded into plain reamed and polished holes in the 3½in thick aluminium bronze tube plates at each end.

Auxiliary Plant

For the range of tests which will be carried out in this wind tunnel it is necessary to be able to vary the mass of air in the circuit to give a range of pressures from 1·5 lb per square inch absolute throughout, under static conditions, to 180 lb per square inch absolute at nozzle inlet with the tunnel in operation at the upper end of the speed range. It is also necessary to be able to hold the pressure constant at any value between these limits against the effect of inward or outward leakage.

A further requirement is that it must be possible to reduce the moisture content of the air in the circuit to 0·00005 lb per lb of air and to hold it below that value.

Study of several alternative methods of meeting these requirements led to the adoption of the following plant arrangements:

(i) A plant to dry air drawn from the atmosphere by compression to 4500 lb per

square inch and cooling to 40 deg. Fah., giving a moisture content of less than 0·00002 lb per lb.

(ii) Storage vessels to store dry air at 4500 lb per square inch in sufficient quantity to enable the peak demands of the tunnel for purging and pressure build up to be met.

(iii) A powerful evacuator plant to reduce to a minimum the time required to purge the moisture initially in the circuit by cycles of evacuation and recharging with dry air.

(iv) A system for packing all glands, seals and joints in the circuit with dry air at above atmospheric pressure to eliminate the need for a by-pass drying plant or for frequent purging of the air in the circuit to expel moisture introduced by inward leakage in the absence of such a system.

Two compressor sets are provided: together these are capable of an output of 300 lb of air per minute at a pressure of 4500 lb per square inch.

Each set comprises a six stage, six crank, double acting, cross-head compressor with three horizontally disposed cylinders on each side of the crankshaft. The compressor is driven by a direct coupled 3·3kV slip-ring induction motor of 1330 b.h.p. continuous rating at a speed of 420 r.p.m. The stroke is 10½in and the piston diameters of stages one to six are 28in, 18½in, 11¾in, 7¼in, 4¾in and 3½in respectively. The mean pressure ratio per stage is 2·6 : 1 resulting in low air temperatures. The fifth and sixth stage cylinders in which the pressures are about 1750 and 4500 lb per square inch are of cast steel and forged steel respectively. All cylinders are water-cooled, as also are the metallic packed glands of the fifth and sixth stage piston rods.

Intercoolers and oil/water separators are provided between each stage. Air delivered by the sixth stage is passed through two coolers circulated with cooling tower water and refrigerated brine respectively. The coolers are followed by an oil/water separator of orthodox design. To remove the last traces of oil/water vapour or mist the air is then passed through a vessel containing a small charge of activated alumina in pelleted form or through paper pack filter candles giving edge filtration, or through both in series. The primary purpose of these final precautions is to eliminate the risk of accumulation of deposits of lubricating oil and iron oxide in the storage vessels: spontaneous ignition of such deposits is known to have been the cause of a number of explosions in compressed air systems. A pressure sustaining valve is fitted between the equipment and the storage vessels to maintain the pressure at 4500 lb per square inch irrespective of the state of charge of the vessels.

Associated with each compressor set is a self contained refrigerating plant of 165,000 B.Th.U. per hour capacity and a 700-gallon brine tank. The refrigerated brine is pumped through the cooler at the rate of 75 g.p.m. and reduces the temperature of the compressed air to 40 deg. Fah. At this temperature and at a pressure of 4500 lb per square inch the saturation humidity is 0·0000168 lb per lb, corresponding to a dewpoint of about −71 deg. Fah.

Of the 300 lb per minute output of the air compressing and drying plant, up to 120 lb per minute may be used for dry air packing of glands, seals and joints, according to the pressure level inside the tunnel and conditions of operation. This leaves a balance of not less than 180 lb per minute available for purging of the tunnel circuit and build-up of pressure level. The volumetric capacity of the complete tunnel circuit is approximately 46,000 cubic feet, equivalent to about 3500 lb of air at s.t.p. conditions throughout or to a maximum charge of about 12,000 lb under running conditions with compressors operating in series at maximum pressure ratio and output pressure. In order to take advantage of the maximum rate of load increase acceptable to the C.E.G.B. (10MW per minute) it should be possible to provide the maximum charge of 12,000 lb in about seven minutes, i.e. at the rate of approximately 1800 lb per minute, which is ten times the rate at which it can be provided by the compressors. Purging the moisture present in the circuit after it has been open to atmosphere requires a number of charges of dry air, each about 3200 lb, to be supplied within a period of about a minute at intervals of five minutes.

The compressed air stored in the reservoirs together with the output of the air compressing plant is sufficient to meet the maximum demands for these purposes for the duration of a normal working day. It is anticipated that under average conditions the compressing plant will be able to replace within a normal working day all the air used during that period, thus keeping the reservoirs fully charged.

Six strip wound compressed air storage vessels, each 4ft internal diameter by 45ft overall length and of 538 cubic feet internal volume, are installed in the open outside the Auxiliary Plant building. They are connected through isolating valves to a bus pipe to give a total storage capacity of 3228 cubic feet, which is sufficient to provide over 60,000 lb of air when the vessels are allowed to discharge between the pressure limits of 4500 lb and 700 lb per square inch.

Each vessel is constructed from a core tube fabricated from 1½in thick rolled plate of "Lowtem" steel, welded at each end to a forged steel plug with a 16in diameter opening. All welding was subjected to radiographic inspection and the completed inner vessels were stress relieved. Eleven continuous layers of interlocking EN34 alloy steel strip, approximately 3in wide by 0·3in thick, were subsequently wound hot over the core tube and end plugs, each end of each layer being secured by welding. On completion each vessel was tested hydraulically to a pressure of 6750 lb per square inch. The total weight of each completed vessel is approximately 67 tons.

Pipework between the reservoirs and the tunnel, which may be subject to sub-zero temperatures as the pressure falls below 4500 lb per square inch on discharge, is fabricated from hot-finished seamless tubing in ½ per cent chrome 1 per cent manganese steel with Charpy V-notch impact value of not less than 15ft lb at −75 deg. Cent. The two sizes of tube used for the main and branch connections are 8⅝ and 4½in o.d., 5in and 2½in nominal bore, and 1⅞in and 1in minimum wall thickness respectively.

Pressure reducing valves maintain a pressure of 250 lb per square inch at a point outside the tunnel for all reservoir pressures between 4500 lb and 700 lb per square inch, and admission of air to the tunnel circuit is through a gate valve remotely controlled from the tunnel control room. A separate system breaks down the pressure to 250 lb per square inch for distribution for dry air packing purposes.

PRINCIPAL CONTRACTORS

Associated Electrical Industries, Ltd., main compressors, motors, gears, coolers and control equipment; The General Electric Company, Ltd., working section leg comprising inlet and outlet sections, adjustable nozzle, No. 1 model support section, calibration section, supersonic diffuser, servo positioning and sensing devices, controls and instrumentation; Constructors John Brown, Ltd., Nos. 2 and 3 model support sections; Harland and Wolff, Ltd., h.p. compressors and air drying plant; Vickers-Armstrongs, Ltd., h.p. air storage vessels; Stewarts and Lloyds, Ltd., h.p. air, evacuator and cooling water pipework; English Electric Company, Ltd., 33kV switchgear main substation, 11kV switchgear variable frequency substation; A. Reyrolle and Co., Ltd., 11kV switchgear main substation, 11kV switchgear ring main substation; Johnson and Phillips, Ltd., 25MVA transformers 33/11kV; C. A. Parsons, Ltd., 20MVA transformer 33/11kV; Ferranti, Ltd., 5MVA transformer 11/3·3kV; Pye, Ltd., closed circuit television equipment; Newalls Insulation Company, Ltd., thermal insulation air circuit pipework; Gamma Rays, Ltd., radiography.

MECHANICAL DESIGN DETAILS OF 4FT BY 3FT WORKING SECTION LEG

By A. L. BAXTER, A.M.I.Mech.E.*

The 4ft by 3ft wind tunnel at R.A.E. Bedford is eventually to incorporate a variable nozzle which is now under construction: the problems posed by the severe and varying temperature and pressure gradients on this assembly and their proposed solutions are explained. Unusual mechanical details elsewhere in the working-section leg are also described here.

THE "High Supersonic Speed Wind Tunnel" at R.A.E. Bedford is, as readers are aware, designed to cover a wide range of not only temperature and pressure but also Mach number. In order to allow large numbers of observations to be acquired in, for a continuous tunnel, short running times, provision was made in the design for varying the air density and the nozzle profile while running. The principal problems in so doing are posed by the variable nozzle, and in fact the nozzle is still under construction. This description of the detail design should be supplemented by reference to the drawing which occupied page 94, July 19, 1957.

Essentially the nozzle comprises two fixed side walls and movable top and bottom walls each 3ft wide by some 26ft long.

The problem of constructing side walls which would be stiff enough to withstand the pressure differential but which would remain flat with varying temperature gradients across them has been avoided. The walls are machined from stainless iron plates to a finished thickness of 1in. These relatively flexible plates are constrained to remain flat by support from stiff backing beams through a system of spring steel links which permit differential expansion in the lengths of the wall plate and supporting beam while carrying the tensile or compressive forces applied by the wall plate. The 180 links used to attach each plate to its supporting beam are water-cooled to prevent conduction of heat and the beams are lagged to avoid temperature gradients caused by radiation or convection.

At the upstream end both the side wall plates and their supporting beams are bolted to the outlet flange of the contraction section. At the downstream end the vertical side walls are located in the longitudinal and horizontal directions by a system of keys to a stiff steel structure known as the bridle which is built

* The General Electric Company, Ltd.

into the foundations and forms the anchor point in the working section leg.

The top and bottom moving walls of the nozzle are each carried by a pair of extremely stiff fabricated steel beams which are pivoted at the downstream end. At the upstream end each pair of beams carries a throat block of fixed contour and is driven upwards or downwards to vary the throat gap by a 6 b.h.p. separately excited d.c. motor through a 400 : 1 reduction gearbox and a $4\frac{7}{8}$in throw eccentric. The variable contour top and bottom walls of the divergent section of the nozzle are formed by flexible plates attached to the throat blocks at a point upstream of the throat. Each plate is machined from a 3in thick rolled plate of 13 per cent chromium stainless iron, air hardened and tempered to give a yield strength of 45 tons per square inch. Over the flexed length of the plates the finished thickness is $\frac{3}{8}$in except for transverse ribs across the back, for jack attachments, which are machined integral with the plates. On the airswept surface of both the flexible plates and sidewalls the standard of flatness aimed at is as specified in B.S. 817 for grade D surface tables, i.e. departures from the mean true plane not exceeding —0·005in over any length of 15ft or —0·0005in over any length of 1ft and surface finish of 20 micro inches.

Each flexible plate is attached to its supporting beams by seventeen pairs of ball screw jacks employing preloading to eliminate back lash. The spacing between pairs of jacks varies from a minimum of 9in at the upstream to 14in at the downstream end. Each pair of jacks is driven through reduction gears by a 0·25 b.h.p. 100 r.p.m. separately excited d.c. motor with class H insulation.

The specification requirements demanded the positioning of the throat blocks and flexible plates to within ±0·001in of the correct profile for the nozzle, and it was therefore undesirable that the resultant air loads on the throat blocks, amounting to about 100 tons on each block, be transmitted through the supporting members for the screw jacks and thence to the bridle structure, the only anchor point on the tunnel.

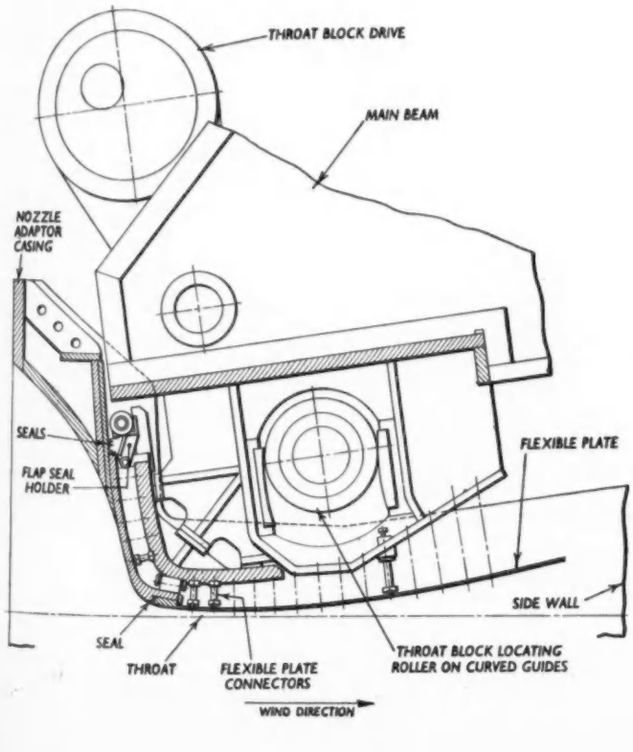
These loads, due to their varying magnitude and direction for different Mach numbers, would have imparted bending moments to the main beams, causing deflections beyond the permitted error value, and it was therefore advisable to contain these loads within the supporting structure as near to the point of generation as possible. For this reason it was decided the nozzle should not be mounted in and form part of the pressure shell ; this offered better access and maintenance facilities to the jacks, but necessitated a far more efficient seal around the throat blocks and flexible plates to exclude moist atmospheric air.

The system finally adopted for containing the air loads consisted of rigidly bolting the main beams to their respective throat blocks, constructed to have four large curved thrust pads mounted within each frame and machined to the correct radius about the true pivot point of each main beam.

These thrust pads bear on two heavy thrust rollers mounted on roller bearings and carried by a massive non-rotating shaft fixed to the side wall support beams of the nozzle by cap type bearings. Thus these large air loads are self contained within the structure over a length of about 5ft of the nozzle, leaving the remaining 22ft to carry only their own loading.

It is evident that the required motion of the throat block controlled by the curved thrust pads is a true rotation about the theoretical main beam pivot, and whilst this gives the correct throat opening for any Mach number, the inflexion point of the fixed profile portion of the nozzle would not necessarily, due to thermal and load deflection causes, be on the correct curve. A means of correcting the position of the inflexion point was therefore introduced at the main beam pivot, consisting of a small throw eccentric, driven by an electric motor through reduction gearing, capable of moving the actual centre of rotation to bring the inflexion point onto its proper position. This correction device, controlled by a servo system, corrects for any thermal or load deflection which occurs during running conditions without the complication of additional equipment.*

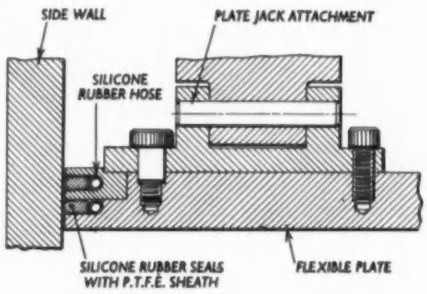
* This device is present but not apparent in the drawing *ante*



Throat block and flexible plate

Due to there being only one anchor point for the whole working-section leg (i.e. the bridle structure) the two relatively thin side walls of the nozzle were required to control the motion of the heavy inlet and contraction sections, weighing some 200 tons, under the thermal changes. It was considered desirable to keep these side walls always in tension, therefore preloaded spring type registers were inserted between the bridle structure and the side wall support beam, capable of maintaining a minimum tension of 6 tons in each side wall.

The sealing of the small gap between the side walls of the nozzle and the throat blocks and flexible plates proved to be the most difficult problem on the whole tunnel, due to the many changes in direction of the surfaces to be sealed, thermal and profile changes, and the requirement that a blanket



Flexible plate and side wall : air seal

of dry sealing air be interposed between the tunnel air and atmosphere. Much experimental work with various seal shapes and methods of loading were investigated by the Research Laboratories of the G.E.C., before the final method of sealing evolved capable of meeting the specified leakage rate, with a falling pressure range of 200 lb per square inch to 30in vacuum, withstanding a maximum temperature of 150 deg. Cent. and flexible enough to meet the changing profile of the nozzle.

The final design consists of two continuous strips of silicone rubber approximately $\frac{1}{4}$in by $\frac{7}{16}$in in cross section, sheathed in a strip of p.t.f.e. tape to reduce sliding friction, and held in contact with the side walls by inflatable silicone rubber hoses, all mounted in a semi flexible carrier. This carrier is attached to the flexible plate by lugs formed on the back of the plate over the variable profile portion of the nozzle, and is held in hard contact with the back of the plate in the region of the throat block by spring loaded bolsters.

The continuity of seal, at the up and downstream ends of the two carrier plates, across the tunnel is maintained by two flap type plates fitted with the same seal section, hose pressurised, and embodying the blanket of dry sealing air and capable of accommodating the thermal and positional changes of the throat block and flexible plate.

At the downstream end of each side wall an aperture of 4ft diameter is provided to accommodate windows for model viewing and the Schlieren system. Two sets of windows have been made, one set of 45in clear diameter for use at normal temperatures and another set comprising steel blanks with four small glass ports for use at high temperatures. To avoid damage to these windows during the initial cleaning and blowing down stages window blanks are provided : there is also a half-model turntable capable of being inserted in one of

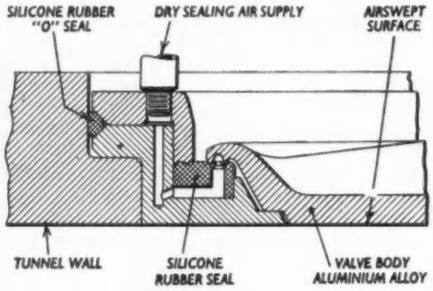
the window apertures, all of which are locked into the nozzle side walls by interrupted threads of the breech block type. These variations necessitated a means of rapidly and automatically changing the ports to suit operating conditions, and is accomplished by means of a two compartment lifting cage and a parking position mounted in each vertical leg of the bridle structure.

Each lifting cage is raised or lowered by two hydraulic cylinders with positive terminal stops which accurately align either window with the aperture in the side wall, and the window, slung on guide rollers, is then rammed into the aperture in the side wall by two hydraulic ramming cylinders and locked in position by a locking ring also hydraulically actuated.

All these window interchange motions are controlled by valves mounted on the top of the bridle structure, and are sequenced and interlocked together to ensure correct operation. A further system of electrical interlocking operating between the control room and working section hall ensures that none of the quick release bolt or window interchange valves can be operated except under direct sanction of the officers in charge.

Under operating conditions the air flow through the nozzle, model support section or supersonic diffuser, can break down due to any one of a number of different reasons, and such a break down causes a very rapid rise in pressure upstream of the diffuser throat—of the order of 15 lb per square inch in 0·1 seconds. Since there were major difficulties in designing the nozzle to withstand the full equalisation pressure in the event of flow breakdown at maximum inlet pressure, two fast acting relief valves have been fitted to the top wall of the diffuser pressure shell at a point upstream of the throat to prevent propagation upstream of a pressure exceeding 2 atmospheres absolute. These provide a total relief area of 960 square inches. Each valve comprises a light alloy disc which, under working conditions, is simply held on its seat by atmospheric pressure with sub-atmospheric pressure inside. On flow breakdown the valves commence to open as soon as the internal pressure exceeds atmospheric pressure. With low mass and a large operating force due to the considerable area of the disc, acceleration to the full open position is extremely rapid. Arrangements are provided to guide the disc and to absorb its kinetic energy at the end of its travel. Air discharged is conveyed by ducting from the top of the unit to a mating duct in the floor and thence outside the building.

These 22 inch diameter relief valves are of the lightest possible weight and open fully in approximately 0·02 seconds, but they also have to be sealed against ingress of atmospheric air under vacuum conditions. It is therefore essential that the seal be of a form that would not offer any delay characteristics to the rapid opening requirement, and to meet these conditions flat silicone rubber rings are inserted in the valve housings, against which two vee shaped ridges concentrically machined on each valve face, press under the action of the valve weight.



Relief valve detail

These vee ridges form an annular space into which the dry sealing air is fed at a pressure of about 3 lb per square inch above atmosphere, but it is an essential feature that the upward force of the sealing air must not exceed the valve weight at any time unless the tunnel pressure rises above atmospheric pressure.

A braking device is arranged on the stem of each valve to arrest and hold the valves after they have lifted, necessitating re-setting by hand, and for this purpose an access door is provided in the valve chamber.

Another sealing problem encountered on the moving panels of the supersonic diffuser, where air leakage along the panel edges from one side of the throat to the other, via the dead air space behind the moving panels, would seriously interfere with the streamline flow of the air, was rendered more complicated by the hinges between the panels also having to be sealed.

After due consideration and bearing in mind that these seals are contained within the pressure shell and therefore not visible, it was deemed inadvisable to use inflatable hoses to hold the seals in contact with the top and bottom plates, thus avoiding the use of flexible feed pipes in positions where leakage or failure could not be readily detected. A series of "Schnorr" spring units, closely pitched and pressing against backing strips of steel with a silicone rubber jointing, was selected to take the place of the hoses, and arranged round the edges of each moving panel. These spring units press on seals formed from short straight lengths of p.t.f.e. impregnated bronze, mounted in a double row and having the joints staggered and a breathing space between each piece to allow for expansion.

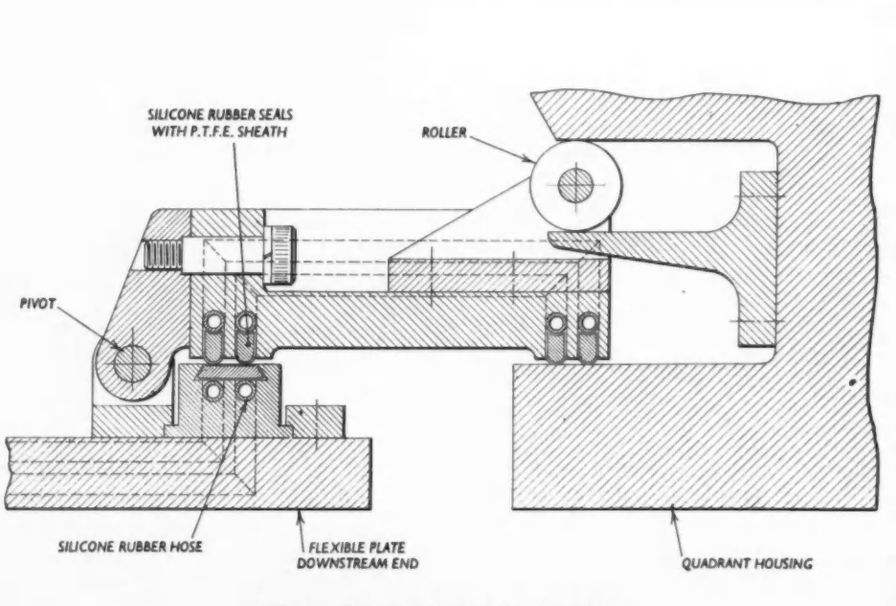
Specially shaped pieces are employed at the corners, and together with the straight lengths of seal along the shorter sides of each moving panel, bear on an additional tubular outer member added to the standard form of hinge to maintain continuity of the sealing surface. This outer member is cut away on the side away from the airswept surface to accommodate the movement of the hinge, and is shaped at each end to accept toroidal "O" rings and spring loaded p.t.f.e. impregnated bronze caps, capable of following up expansion and closing the gap between the end of the hinge and the top or bottom plate of the diffuser shell.

The downstream section of the tunnel can be opened to examine or change a model with the casings still warm and be closed again after cooling down to ambient temperature, giving a considerable variation in length between the two broken flanges, and also in the distance between the tunnel centre line and the centre of the return pipe to the compressors. These variations are of the order of 0·3in and 0·047in respectively, and therefore demand a mechanism capable of aligning and squaring up the outlet flanges before they are brought together, so as to allow the entry, into their respective nuts, of the sixteen quick release bolts which secure these flanges.

To meet this requirement, the mating flange to the outlet casing together with a tail pipe was included in the G.E.C. contract, this tail pipe is welded to the return pipe to the compressors and incorporates the alignment mechanism, consisting of a carrier trolley made in two parts. The lower portion is wheel mounted and runs on floor mounted rails in an axial direction, whilst the upper portion consists of a rotating table mounted on the lower part and having two long rocker arms on its upper side with limited movement in a transverse direction.

The tail pipe is supported on these rocker arms and is thus capable of movement in two planes at right angles and at the same time rotation to bring the mating flanges parallel and onto the same centres.

The rotational and transverse motions are operated by a long probe arm rigidly bolted to the outlet casing, which engages with four additional horizontal rollers carried on the top side of the upper portion of the carrier trolley, whilst the axial motion is permanently biased in a downstream direction by two hydraulic cylinders. These cylinders are fed by constant pressure from an air loaded accumulator in the q.r. bolt pump unit, and are so proportioned that the main traversing unit for the downstream section can easily overpower them, allowing the carrier trolley and outlet flange to move axially to suit the mating of both broken flanges.



Flexible plate downstream : air seal details

Large Diameter Bored Piles

*A symposium on large diameter bored piles was held in London by the Reinforced Concrete Association on March 15. Six papers were presented. Here we give abstracts from the introductory paper by Mr. M. J. Tomlinson, M.I.C.E.**

OVER the last ten years the use of large diameter (i.e. 30in or over) bored piles in Britain has increased to a considerable extent, particularly over the last two or three years. This is due to two mains reasons: first, to the present-day tendency to build high, with consequent increase in column loads of framed structures; and, second, to the development of efficient mechanical rigs for boring large diameter holes to depths of up to 200ft. There is nothing new in large diameter deep foundations. They were used in Chicago and New York nearly seventy years ago to take the foundations of skyscrapers down through deep deposits of sands and clays to rock. The only difference is that these earlier deep foundations employed mainly hand methods of excavation within concrete or steel caissons or in timbered shafts. The well-known "Chicago method" developed by William Sooy Smith (1830–1916) uses vertical timber sheeting supported by circular steel walings.

The present-day use of piles to support high buildings in London results from the need to avoid excessive settlements of foundations bearing on the compressible London Clay. For example, a twenty-storey building imposes a gross loading of about 2½ tons to 3 tons per square foot of plan area. Under this loading the settlement of a raft foundation at basement level might well amount to 9in or more, and the corresponding differential settlements would be intolerable to normal structures. It therefore becomes necessary to take the foundations down to less compressible London Clay at depths of 60ft or more below ground level, or alternatively to reduce the net loading on the soil by deep basements, or a combination of the two methods. In Central London the construction of deep basements may be difficult and costly because of the need to underpin adjacent buildings and other complications such as the presence of underground railways. Their construction is time-consuming, thus delaying the commencement of the revenue-earning life of the building, and in any case deep basements may be of no economic value to the building owner. In most cases, therefore, the usual practice is to adopt deep piled foundations with shallow basements or no basements at all.

Buildings of twenty-storey height are likely to have column loads of up to 1000 tons. If ordinary piles are used, say, 20in to 22in diameter piles of 90 tons nominal maximum capacity, a pile group about 15ft square will be required with a correspondingly heavy pile cap. Also, with columns at normal spacing it is likely that such large groups will be nearly touching each other and it becomes necessary to combine the pile groups into a large and heavy raft. The alternative of providing one single large pile beneath a column is therefore attractive. However there are a number of complexities involved in the design and construction of large diameter piles which are discussed below.

* Chief Engineer, Central Laboratory, George Wimpey and Co., Ltd.

Pile Design from the Soil Mechanics Aspect

The introduction of large diameter bored piles has greatly stimulated the calculation of carrying capacity by "static" or soil mechanics methods. Previously specialist contractors installing proprietary types of bored and cast-in-place piles relied on "rule of thumb" or past experience based on test loadings to assess the working loads. It was the usual practice for such contractors to tender on the basis of putting forward their own recommendations for the diameter and length of piles for a given working load, and if the piles failed to carry the test load they would be required to provide additional piles or larger or longer piles. Needless to say, the recognised specialist contractors are jealous of their reputation to provide piles of adequate capacity and cases of failure under test load do not often occur: collapse of structures owing to the failure of piled foundations is very rare indeed.

Because large diameter bored piles are a comparatively new development in Great Britain there is little experience to guide engineers and contractors in the calculation of their carrying capacity and long-term settlement. Generally attempts are made to assess their ultimate carrying capacity as given by the sum of the skin friction or adhesion and the base resistance. The ultimate carrying capacity is divided by an arbitrary safety factor to give the maximum safe carrying capacity of the individual pile. Since it is usual to adopt a safety factor of 2½ or more the calculated ultimate carrying capacity may be of the order of several thousand tons which makes test loading to check the validity of the calculations a highly expensive procedure; so much so that the engineer may decide to limit the test loading to, say, 50 per cent above the working load, applying the test to one of the permanent piles. Thus there has been little opportunity, up to the present time, for engineers to prove to their own satisfaction that the current methods of calculation of carrying capacity by "static" methods are basically sound.

In the author's opinion the normal procedure of dividing the ultimate carrying capacity of all piles in a structure by the same arbitrary safety factor is open to doubt. In almost all cases of large diameter bored piles on compressible soils, whether these are clays, sands or gravels, the allowable working load is governed by considerations of the permissible total and differential settlements of the structure. Therefore, if the columns of a building carry widely varying loads, it may be necessary to vary the safety factor for each pile or pile group in order to prevent excessive differential settlement. It is the normal practice to determine allowable bearing pressures on heavily loaded strip, pad or raft foundations from a settlement analysis, and the maximum safe bearing capacity for such foundations, as calculated from the ultimate bearing capacity divided by an arbitrary safety factor, is only used as a preliminary guide to the selection of bearing pressures in the settlement analysis.

Carrying Capacity Based on Settlement Analysis

For the reasons stated above the author suggests that the same procedure should be used for large diameter bored piles as is used for shallow foundations, i.e. allowable settlement both of individual piles or pile groups and of the whole structure should be the criterion of design rather than ultimate carrying capacity of the individual piles. Unfortunately the settlement analysis of deep foundations, which derive their carrying capacity partly from skin friction and partly from end-bearing, is far from straightforward, and the mechanics of load sharing between these two components is not fully understood. This is particularly true where enlarged bases are adopted.

It is gratifying to note that the Institution of Civil Engineers is to conduct a research programme to study the load settlement characteristics of deep bored cylinders. The results of this work should be of outstanding significance, and should do much to resolve the present uncertainties in making settlement analyses for foundations of this type.

Large Diameter Bored Piles in Rock

Where large diameter bored piles are bearing on hard rock such as granite, hard sandstones and massive hard limestones their allowable carrying capacity is governed by the permissible stress on the concrete in the pile shaft. However, in the case of piles in soft rocks such as marl, chalk, shale and weak sandstone there is no satisfactory basis for design. The use of arbitrary figures of bearing capacity given in handbooks or "Codes of Practice" is likely to be uneconomical in cases where piles have to be taken down to a considerable depth to reach the rock. The author has heard of a case where a higher working load has been permitted for ordinary precast concrete piles driven to refusal in rock than for large bored piles three or four times their size founded on the same rock. In the first case a dynamic formula was used to calculate the working load, in the second case the allowable bearing pressure was taken from building regulations appropriate to shallow foundations.

The development of the science of rock mechanics is needed to enable allowable bearing pressures to be calculated on a realistic basis.

The Effect of Constructional Procedure

Skempton has shown that the ultimate adhesion of bored piles in London Clay varies from 0·3 to 0·6 of the shear strength of the clay with an upper limit of 2000 lb per square foot. He suggests that the adhesion factor is, *inter alia*, related to constructional methods; the lower factors being the result of softening of the clay due to exposure when a long time is taken to install the pile, to seepage of water down the pile shaft, or to the absorption by the soil of excess water in the concrete. In the case of long straight-sided piles in clay a high proportion of the load is carried in adhesion, and therefore the selection of the correct adhesion factor is a matter of utmost economic importance. Deep and large diameter bored piles inevitably take longer to drill and concrete than ordinary piles, and it is quite wrong to assume that delays will not occur from time to time. Where the piles are mechanically underreamed it is by no means unusual for the

under-reaming tool to break off down the hole on striking clay-stones. Enlarge bases made by hand excavation may take four or five days to complete in the very large diameters, and in fissured clays there is a risk of collapse of the enlarged hole. These contingencies should be allowed for in the design by assessing the adhesion factor in the lower range of values. Very low values of shaft adhesion will also affect the analysis of settlements since they will tend to throw increasing load on the base of the piles. Delays in constructing the piles may also lower the end resistance if water is allowed to collect in the base, or if the clay in the base becomes puddled and softened by operations to recover a broken tool or clear collapsed debris.

The occasional small diameter pile " going wrong " has no serious consequences. It is a comparatively simple matter to put an extra pile on either side of the defective pile with a comparatively small enlargement of the pile cap. Where, however, heavily loaded columns are carried by single piles it may be impossible, for structural reasons, to do this. Each large diameter bored pile is an important foundation structure in its own right, and the utmost care and conscientiousness is required in construction.

Royal Institution of Naval Architects

ANNUAL SPRING MEETING

No. I

THE morning of Tuesday, March 28, marked the opening of the Spring meeting of the Royal Institution of Naval Architects in the Weir Lecture Hall, at 10, Upper Belgrave Street, London, S.W.1, with the President, Viscount Runciman, in the chair. The secretary gave a summary of the annual report and this recalled the celebration of the Institution's centenary and the presentation of Diplomas of Honorary Membership, during that event, to past presidents, Admirals of the Fleet Lord Chatfield and Viscount Cunningham of Hyndhope, Monsieur A. Augustin-Normand and Dr. P. T. Pereira. It also records the election of Lord Runciman as an Honorary Member and of Sir Victor Shepheard to be an Honorary Vice-President. All grades of membership totalled 4538 at the end of 1960 compared with 4358 on the same date in 1959, an increase of 180.

The Gold Medal of the Institution was announced as having been awarded to Mr. J. E. Conolly, B.Sc.(Eng.), for his paper " Strength of Propellers," and a joint premium has been awarded to Mr. I. M. Yuille, B.Sc., Ph.D., and Mr. L. B. Wilson, B.Sc., for their paper " Transverse Strength of Single Hulled Ships." Lieut-Commander G. W. R. Nicholl was awarded the Samuel Baxter Prize for his work and book " Survival at Sea." It was noted in the report that 104 Higher and 145 Ordinary National Certificates in Naval Architecture had been gained and that forty-seven holders of the Higher National Certificate had been awarded Endorsement Certificates in Theory of Naval Architecture and Design. Duke of Northumberland Prizes were noted as being awarded to Mr. R. P. Browne, of Poplar Technical College, and Mr. J. Barker, of Isle of Wight Technical College, while the City and Guilds of London Institute's examination awards were won by Mr. K. R. Chapman and Mr. B. L. A. Norris.

Revision of the By-Laws and Regulations subsequent upon the grant of the title " Royal " were noted, also the formation of a new class of membership, namely " Student-Associates," and a law relating to professional conduct. A Summer School for teachers of Naval Architecture was announced, to be held at the College of Aeronautics, Cranfield, from July 23 to 29, and the report gave particulars of the work of the Southern Joint Branch and the election of Mr. G. M. Kennedy in succession to Mr. H. E. Steel. Short notes described the work carried out in 1960 by the British Shipbuilding Research Association, the Ship Division, National Physical Laboratory, Pametrada, and the British Welding Research Association. Changes in the conditions governing scholarship awards and in their value were mentioned and the report listed the following scholarship awards : The Royal Institution of Naval Architects to Mr. M. A. Cubitt, of Vosper, Ltd. ; the Vickers-Armstrongs to Mr. B. T. Proctor, of Trinity Academy, Edinburgh ; and the Post-Graduate Research to Mr. B. S. Bowden, B.Sc., of King's College, Newcastle upon Tyne. After the presentations of awards and the adoption of the report and of the accounts, presented by Sir Victor Shepheard, Viscount Runciman gave his address, an abstract of which appears below.

The President's Address

It is the custom that in his address to the Annual General Meeting the President should confine himself to the domestic matters of the Institution as distinct from matters concerning the outer world. That practice I propose to follow and to touch on matters of importance to the Institution. The first is that of our membership, about which I should like to say two things. The largest relative increase is in the number of Students, and I think that is something about which we may feel satisfaction, since it is by the increase in the number of Students that we may best hope to swell the ranks of our professional members in the years ahead.

There is a slow increase in Associate-Membership and full Membership of the Institution, for which I think there are probably two reasons. It may well be that those who have joined the Institution in one class of membership are content to remain there, or it does not occur to them to apply for a higher class of membership when qualified to do so. The second reason is that the qualifications required are too exacting, but we should be ill-advised to let them slip in any way with the object of enlarging the membership.

Concerning the By-Laws, there is for the first time a by-law referring to professional conduct, and one related to the foundation of the new class of membership, " Student Associates." I think that it is useful because the class of Associates is one which has rendered some service to the Institution in the past, and is a useful link between the narrower aspects of the naval architects' profession and those wider ones of which we have to take account.

Now I come to authorised abbreviations, and you will notice that in the new By-Laws the authorised abbreviations for Honorary Member, Student and Student-Associate no longer apply.

The Privy Council has for some time noticed the prolification of the use of letters after names, and to that it has drawn our attention. Clearly it cannot make the slightest difference to an Honorary Member or a Student or a Student-Associate whether or not he puts letters after his name which imply no professional qualifications whatever, and I think it is right that the abbreviations mentioned should disappear. The Privy Council has gone a little further and has raised the same question in connection with Associates. Associates form a valuable part of the Institution's membership, but their qualifications are those of persons associated with the profession of naval architecture, but who have not the qualifications of a naval architect. The Privy Council has therefore suggested that at the next revision of the By-Laws we should consider abolishing the authorised abbreviation for Associates, on the grounds that it could be misleading, as suggesting professional qualifications which Associates are not required to possess.

There is another question of a rather similar kind to which I invite the Institution to give some thought as time goes on. It is that in our Council we are a working body, and our vice-presidents and honorary vice-presidents are rightly required by us to perform certain duties, and to continue to play an active part in the affairs of the Institution. If you look carefully through the book you will find that there are persons holding higher offices in the Institution, but who have not been near the place for years. What I would like to suggest, is that you might seriously consider whether some qualification might not be put into the By-Laws requiring a person who has found himself unable to attend the Institution for more than a fair period of time to vacate his office, to which he has previously been elected.

Coming to other matters, we look forward to a visit to Sweden in September this year. In October there will be held at Devonport the first of what we hope will be a series of informal meetings outside London, to enable those of our members who find it difficult to come to London at frequent intervals to discuss matters of common interest and keep in touch with the Institution's work. We have received and have accepted an invitation to meet in Ireland, starting in Dublin in June, 1962, where the Institution last visited in 1903, and it is proposed to make a visit on that occasion to the recently established shipyard at Cork.

This is the last time I shall address you at an Annual General Meeting from this Chair. Therefore I would like to express my thanks to the members of the Institution for their kindness, courtesy and consideration to me over a period of ten years ; to say what great satisfaction and pleasure it has given me to preside at both the Council meetings and other gatherings of the Institutions ; to wish the Institution every success in the future.

(*To be continued*)

Motor Vehicle Statistics.—The March, 1961, *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders, Ltd., includes figures for the output of the main producing countries in 1960. This country was the largest producer of buses, with 19,048, the second largest producer of commercial vehicles, with 438,924 (U.S.A., 1,190,313) and the third largest producer of cars, with 1,352,728 (U.S.A. 6,674,796, West Germany 1,816,779).

MAINLY METALLURGY

Instability of Semi-Brittle Steels at Room Temperature under Torsional Impact

By J. B. HUNT, M.Eng., B.Sc.(Eng), A.M.I.Mech.E.*

THE extensive work of Itihara[1] and Work and Dolan[2] indicates that the static and dynamic torsional testing of heat-treated mild steel specimens at room temperature (20 deg. Cent.) always yields a torque-twist ($T-\phi$) relationship shown graphically by a curve with a slope gradually approaching zero and never becoming negative, shown in Fig. 1.

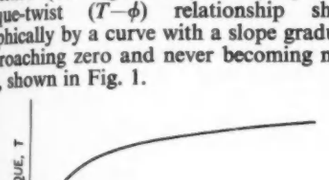


Fig. 1

The author tested untreated solid mild steel cylindrical specimens cut from bar in the as-received, i.e. untreated, condition, and found that the normal static torsion test at room temperature produced the usual curve. The dynamic tests, however, produced a negative curve shown in Fig. 2 indicating

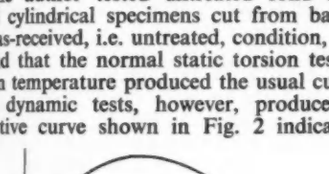


Fig. 2

dynamic instability and inhomogeneous yielding of the material. A possible explanation for this apparent non-conformity was propounded from the investigations which followed.

Fracture Mechanism

If a brittle material is subjected to torsion, tensile failure takes place almost immediately. If a cylindrical specimen made of a semi-brittle material is twisted, tensile microcracks form on the periphery of the specimen as shown in Fig. 3. These are not propagated

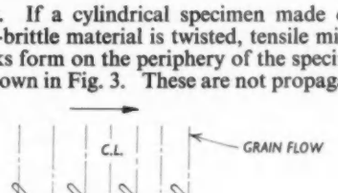


Fig. 3

to a sufficient extent to cause complete separation, the propagation being arrested by the more ductile parts of the material. This process was suspected by Nadai.[3]

As twisting proceeds the crack orientates until it is axially placed. The grain flow direction at the surface of the specimen has then been turned through 45 deg., as shown in Fig. 4. The author has shown earlier[4]

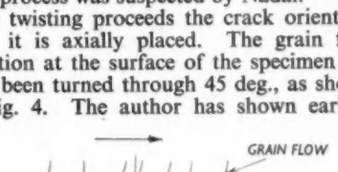


Fig. 4

that shearing then takes place in the grain flow direction between points *A* and *B*.

Instability

Since there is no resultant axial force impressed externally on the specimen the axial component of the force required to shear the specimen along the line *AB* must be resisted internally. This resistance is supplied by a tensile stress at the core. Hence, though the cylindrical specimen is subjected to pure torsion only, separation is taking place in direct tension and in shear simultaneously. At high rates of strain the yield point in shear and tension increases. Surface strain is increased and the torsional moment applied increases. At high strain rates the direct stress-strain curve for mild steel specimens shows a negative slope after yielding, Manjoine.[5] Therefore, in the case of impact torsion, as soon as the tensile load at the core is reduced, the shear force and hence the applied torque is likewise reduced. This produces the $T-\phi$ curve with a negative slope indicating torsional instability.

Results

Two steels were tested, *A* and *B*. The chemical composition is given in the table below.

	C	Si	S	P	Mn
A	0·14	0·05	0·022	0·012	0·89
B	0·15	0·034	0·042	0·012	0·55

The material was bought in standard lengths of ½in square bright bar. The ¼in diameter specimens were machined directly from the bar and were untreated. The surface finish of the specimens had a C.L.A. of 25μ.

The static and dynamic results for these two steels are given in Figs. 5 and 6.

Conclusions

Because the steels chosen for testing were of commercial grades bought " off the shelf," and not subjected to any special preparation or treatment, the results are of practical importance to steel users in emphasising that a dynamic torsion test is not merely a rapid static test. Work is proceeding on tests at low temperatures. Indications are that the instability is even more sensitive to sub-normal temperatures than to high strain rates.

References

[1] Itihara, M., 1935, Technology Reports, Vol. XI, Tôhoku Imperial University, pages 489–581, " Impact Torsion Tests " (No. 2, No. 3, and No. 4).

[2] Work, C. E., and Dolan, T. J., 1953, Eng. Exp. Station Bulletin, No. 420, pages 1–108, University of Illinois, " The Influence of Temperature and Rate of Strain on the Properties of Metals in Torsion."

[3] Nadai, A., 1950, *The Theory of Flow and Fracture of Solids*, page 203, McGraw-Hill, New York.

[4] Hunt, J. B., 1958, *Journal of Mech. and Phys. of Solids*, Vol. 6, pages 321–326, " Fracture Mechanism of Semi-Brittle Steels in Torsion."

[5] Manjoine, M. J., 1944, *Journal of Appl. Mechs.*, Vol. 11, No. 4, pages 211–218, " Influence of Rate of Strain and Temperature on Yield Stresses of Mild Steel."

* University of Southampton.

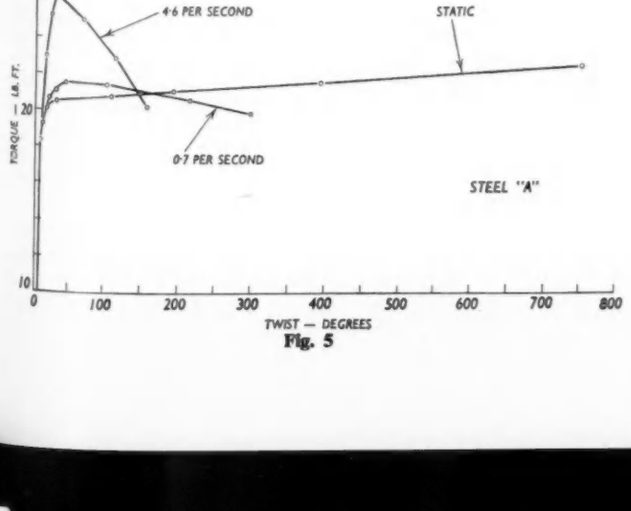


Fig. 5

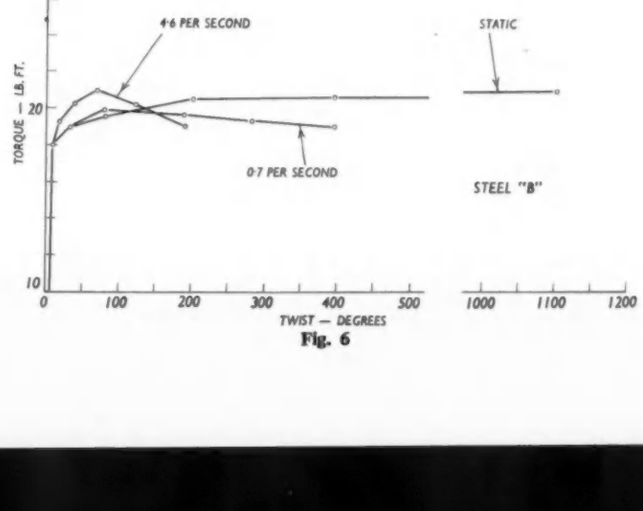


Fig. 6

LETTERS AND LITERATURE

Letters to the Editor

MILLIONS TO BE SAVED?

SIR,—I have read Mr. H. Roy Guenin's letter with interest, but feel that to infer that ones opponents in debate are in need of mental attention is a poor line of argument. It seems unlikely to me that THE ENGINEER would suggest the conversion of a substantial stretch of main line if the arguments put forward by the Railway Conversionists had not been worthy of a fair trial.

If the 164 mile long Great Central Line between Sheffield and London were chosen for such a scheme, and if Brigadier Lloyd's figures of 60 miles in the hour bus travel at fares of ½d. per mile prove correct, then Mr. Tuplin would be able to travel to London for 6s. 10d. in 2¾ hours. I wonder if these people who complain that all factual arguments are unavailing have themselves read Brigadier Lloyd's very logical book, *Twilight of the Railways*, with an open mind.

R. E. INGHAM, B.A. Engineering

Harrogate,
March 28, 1961.

SIR,—In reply to Mr. T. I. Lloyd's letter in your issue of February 24, it appears that he has missed the point of my letter altogether. The Southern Region of British Railways is not " playing trains," but transporting passengers, in safety, and in so doing under the present extremely limited conditions at London Bridge the train frequency is regulated by the speed with which passengers board the trains. Mr. Lloyd solves this problem by expecting his forty-seater buses to stop, allow ten passengers to board and be under way again in 7½ seconds !

In conclusion, the bus headway which I quoted was on the lines passing through London Bridge Station on three tracks. The Borough Market Junction with only two tracks would therefore require a bus headway of five seconds. It is obviously impossible to compare Borough Market Junction with an American trunk motorway.

N. PALLETT

London, S.E.6.,
March 23, 1961.

SIR,—May I add to the spate of words already penned on the controversial " railway conversion " subject?

Bringing the matter of purely passenger transportation down to basic principles, it must surely be quicker, more comfortable and more economical to transport 600 people on one connected and integrated train, than on a minimum of ten individually controlled vehicles. To transport 300,000 passengers into one area by super coaches, multiply this solution or equation by 500. But the solution produces 40,000 uncertainties, being 5000 individual decisions of drivers, 30,000 tyres and a nominal 5000 mechanical or electrical ones. Any one uncertainty will produce dislocation and a long queue of traffic in a short time. A similar transportation by 500 trains would reduce the number of uncertainties to a mere 1000. For local inter-station work and the off-peak periods an extension of the present railcars fleet would provide all that coach transport could provide, with the added safety of rail guides under adverse weather conditions. I would even extend the railway facilities to tap the changed centres of population, pruning or cutting the old as necessary. Railcars have the facility of physically connecting with others or with another train at major points and so avoiding " passenger interchange."

On the matter of bulk transportation of heavy loads : heavy loads are the function for which the railways were designed and they must recapture this basic traffic. If tax depreciation allowances on vehicles was discontinued, and the prime cost of the vehicle was borne by the manufacturer wholly, the load carrying would quickly be put back into its rightful channel. (This depreciation allowance must of course continue for the genuine road haulier.) Door to door transportation which is the bastion of the producer/manufacturer in this argument, would still be possible, by the provision of bulk containers. Each container could and should be capable of being lifted from/to the railway flats to/from railway vehicles for the first/last step of their journey. Local vehicular traffic would still be necessary for the short haul, but for long distance haulage—no!

To make this outline a fact there is a requirement on the passenger carrying side for :

(1) At major termini, a cloverleaf tunnel or over-road rail route of possibly three track to allow trains to enter and leave the station without retracing their route.

(2) A two part station, each section of which could then concentrate on the reception or dispersal of the passengers in large concentrations at peak hours with multiple moving stairways or links to " local " lines or bus routes. A stagger or headway of perhaps thirty seconds would permit six trains containing say 4500 passengers to disgorge on to six platforms in three minutes allowing three minutes for each train, which would depart empty to its pick up point. This figure could no doubt be open to improvement.

(3) A direct connection either over-road or overhead or by a circular route connecting north and south London avoiding a direct change at this terminus, which is perhaps a " peculiar " in the country's railway system.

To deal with heavy goods transportation, alterations must include, two-levels at major stations so that direct loading from rail to road is both possible and practical, with considerably increased lifting and loading facilities on the main routes to load and off-load containers. Conversion of a fleet of lorries for local transportation of these containers within a 20-mile radius of the major stations. Considerable increase in numbers of both open or closed containers. Expeditious transhipment of cargo must be the aim and object to encourage custom.

The streamlining of our transportation would attract many cars from the medium and long distance roads, which should provide increased car conveyancing, complete with luggage and passengers. These would entail ramp access at major stations. The railways should wash their hands of small parcels, including small livestock traffic and handle this in bulk through the post office channels. Other livestock would continue to be handled by the railway heavy goods on similar lines in transportable livestock containers. Removal of the heavy traffic from the major routes would make many of our roads capable of sustaining and increasing their load of light traffic. While I am in favour of a modern roadway system, the building of major highways where judicious improvement of existing main routes would serve almost the same purpose, should not be allowed to get out of hand.

These are the broad outlines and I must agree with the many who rightly expect that in this day and age we should be able to plan for the best of both rails and roads. Each has its problems its capacity and its rightful place in our transport system.

D. J. CONNELL

Catterick Camp,
Yorkshire,
March 28, 1961.

NATIONAL WATER GRID

SIR,—I was puzzled by Mr. Pownall's letter in your issue of March 10 on the National Water Grid, but have now unearthed two publications of his that give explanations of his proposals for a Grand Contour Canal (G.C.C.), but still leave the puzzle.

The first is a pamphlet dated January, 1942, called " The Projected Grand Contour Canal," which contains statements (see pages 10, 16 and 20) that the canal would be a one-level canal, a canal without any variation in level, a canal having no locks, &c. Further it is said that the canal will take vessels up to 1500 tons, up to 35ft wide by 25ft deep by 250ft long.

But also on page 20, Mr. Pownall says : " At each 12 miles interval the fall of water surface of 1ft or less would be restored by a low lift pump associated with a lock of simplified form to pass the traffic."

On page 24 there is a table of lengths of reaches and costs, which shows 491 miles of " Main Line " canal with nine main terminal lifts and twenty-four minor lifts for barges. This does not agree with 491 miles of main canal with a minor lift every 12 miles.

The second document is a reprint from *The Water and Sanitary Engineer* for May, 1952, called " Water Supplies and the Grand Contour Canal." It re-affirmed that the

canal would be ideal for navigation as there would be no locks (paragraph 4), but adds in paragraph 14 : " The means of restoring the 1ft drop in level at intervals in such a way as not to delay navigation would make an interesting minor problem."

Other " minor problems " seem to be the method of filling the canal in the first place and maintaining a discharge of 2000 cusecs (Mr. Pownall's figure) in the second. The effect on surface flows (rivers and run-off) and on sub-soil water levels and drainage would also interest farmers on both the uphill and downhill sides of the canal. The design of the nine main lifts, each for 310ft, would interest engineers, too.

F. NEWHOUSE,

Twickenham,
March 26, 1961.

Book Reviews

The Bargainers. By GEORGE CYRIAX and ROBERT OAKESHOTT. Faber and Faber, Ltd., 24, Russell Square, London, W.C.1. Price 21s.

THE authors of this volume have made a real contribution to the discussion of one of the most vital issues in contemporary domestic affairs. What is the function of a trade union and how should it carry it out ? Both of them are specialists in labour problems—Mr. Cyriax on the staff of the *Economist* and Mr. Oakeshott on the staff of the *Financial Times*—and they show themselves to have not only a detailed knowledge of the activities of trade unions in the post-war period, but also the detachment to analyse and assess them.

The great job of the unions in the past was to fight to assure their members a decent standard of living, to protect them against the exploitation of employers who had little concern for the welfare of workers, and to provide a modest buffer between the incapacitated or unemployed worker and sheer destitution. In addition to their main work of industrial negotiation, they acted as the spur to the public conscience or as an agent of social morality to defend the oppressed and the underdog.

To-day their job is nothing like so clear cut. Decades of wage bargaining have established the idea of occupational rates of pay and twenty years of full employment have pushed those rates up. The change in the climate of social opinion has made it very much less likely that any firm will " grind the faces of the poor " even if an opportunity to do so presents itself and half a century of social legislation has reduced the friendly benefit side of the unions' work to relative insignificance. In a dynamic economy in which the whole complex of market conditions is perpetually changing, the work of industrial negotiation remains as necessary as ever. The individual workman has neither the knowledge nor the power to ensure that his pay and working conditions are the full amount of his worth to the employer and the union is essential to provide him with this business service. But the unions can no longer pretend that they have the moral function of protecting the powerless, the poverty-stricken and the oppressed. There are, unhappily, such groups still in the community ; but they consist of the old and of deprived children and not of the members of powerful unions.

Unfortunately, attitudes of mind do not alter as rapidly as circumstances and many trade unionists—and those who criticise them—approach the problems of to-day with minds set in the moulds created half a century ago. It is the merit of this book that, whilst it recognises and values the traditional ideas and ideals, it attempts to examine the problems of the present time within their contemporary context. How far, for example, have changes in industrial structure and in developments in the ease of communications given to the shop steward in the factory the importance that used to belong to the union branch ? For most workers to-day trade unionism begins and ends at the place of work and to them the shop steward *is* the union; but union constitutions, fossilised in the past, do not provide for him any suitable place in the official heirarchy nor any positive sphere of control—hence the constant unofficial strikes.

It is questionable, indeed, whether with the great increase in the size of the individual firm, it is now as certain an advantage to the worker as it used to be for all wage negotiations to be carried on at national level. Perhaps the time has come to follow the American example of using the profitable enterprise as a pace-setter in rates and conditions ; but here again long standing procedure acts as a bar.

Mr. Cyriax and Mr. Oakeshott have discussed so many important matters that it is impossible even to list them in a short review. But in addition they have provided the best account yet available of the actual day-to-day working of the unions. Anybody who wants to get a clear, well-documented account of the nature and characteristics of modern trade unionism and an opportunity to understand the issues that confront mid-twentieth century unions could not do better than study this work.

Energy Theorems and Structural Analysis. By J. H. ARGYRIS, D.Sc. (Eng.), and S. KELSEY, B.Sc. (Eng.). Butterworths Scientific Publications, 88, Kingsway, London, W.C.2. Price 21s.

THIS book comes to the reviewer much like the siren voices to the seafaring Odysseus. The lure of engineering reduced to abstractions and diagrams, where problems have clear cut solutions, is strong. All that seems to be required is a plentiful supply of paper, a certain mathematical facility, and—let us admit it—painstaking, prolonged, and meticulously accurate hard work to attain the ideal Platonic solution which has been stored up in some engineers' heaven. Alas ! For a safe journey to most of our destinations these voices must be resisted. It is only the exceptional engineer whose ears may be free to listen, and it is perhaps a good thing that most such men are firmly tied, if not to the masts of the classical barques, then to their academic chairs.

Professor Argyris' book originated from work on aircraft structures, and there indeed the elastician is in a strong position. He shapes the structure, he must work to close limits, and his factor of safety (ignorance ?) is small. For the engineer whose practice is more mundane, other considerations are of greater importance. Compromise becomes necessary, corners must of needs be cut, metaphorically and literally ; and time is of the essence. All these might be excuses why structural engineers and the like do not often embark on analyses of highly redundant structures, and when they do so prefer to keep the mathematical approach to a minimum in favour of the physical. The engineer is much like a general practitioner in medicine ; knowing his limited range of bottles, and having many patients to attend to. The temptation to refer any difficult case to the specialist or simplify it to fit one of the standard categories is considerable.

Dr. Argyris' book, especially in its later sections where he works through a number of examples, does help. The δ_{ik} method and its counterpart, the flexibility and stiffness matrix equations, are becomingly increasingly and deservedly familiar to engineers, and may perhaps soon become part of his everyday equipment. It is over 100 years ago since a justly famous engineer, having to calculate the deflection of a bridge girder, was forced to call in the aid of a " mathematician," and the rate of progress has speeded up since. What is perhaps wanted is a treatise in which the mathematical treatment and the basic work—important though it is—is curtailed still further and the practising engineer presented with something like Kleinlogel's book as a guide to dealing with indeterminate structures of various kinds. These criticisms should not be taken as directed against Dr. Argyris' book, rather against the mass of his potential readers. For whilst the aerodynamicist may not flinch from pages of symbols, the average structural engineer certainly tends to do so, and must be gradually weaned from his slide-rule and section-book. If he can overcome his distrust for the Greek alphabet, and give Dr. Argyris' and Mr. Kelsey's book the attention it deserves, he will certainly not be the loser by it.

Books Received

Stability of Coastal Inlets. By P. Bruun and F. Gerritsen. North-Holland Publishing Company, Amsterdam. Price 23s.

Engineering Management. By Straun A. Robertson. Blackie and Son, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 30s.

The Machining of Steel. By F. C. Lea and Eric N. Simons, Odhams Press, Ltd., 96, Long Acre, London, W.C.2. Price 21s.

Mechanics for Textile Students. By W. A. Hanton. Butterworths Publications, 4 and 5, Bell Yard, London, W.C.2. Price 30s.

Basic Naval Architecture. By Kenneth C. Barnaby. Hutchinson and Co. (Publishers), Ltd., 178-202, Great Portland Street, W.1. Price 50s.

Concrete Materials and Practice. Third edition. By L. J. Murdock. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1.

Irrigation and Hydraulic Design. Vol. 3. By Serge Leliavsky. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 273s.

Semiconductor Technology. Edited By G. K. T. Conn. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 10s. 6d.

The Antenna. By L. Thourel and translated by H. de Laistre Banting. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 70s.

Principles of Stellar Dynamics. By S. Chandrasekhar. Dover Publications, Inc., 180, Varick Street, New York 14, New York. Price 2.00 dollars.

The Dynamics of Rigid Bodies. By William Duncan MacMillan. Dover Publications, Inc., 180, Varick Street, New York 14, New York. Price 2.00 dollars.

A Manual of Spherical and Practical Astronomy. Vol. 2. By William Chauvenet. Dover Publications, Inc., 180, Varick Street, New York 14, New York. Price 2.75 dollars.

Thermoelectric Materials and Devices. Edited by Irving B. Cadoff and Edward Miller. Reinhold Publishing Corporation, New York, Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 78s.

Steel Designers' Manual. Second Edition. By Charles S. Gray, Lewis E. Kent, W. A. Mitchell and G. Bernard Godfrey. Crosby Lockwood and Son, Ltd., 26, Old Brompton Road, London, S.W.7. Price 50s.

Tables of Thermodynamic and Transport Properties of Air, Argon, Carbon Dioxide, Carbon Monoxide, Hydrogen, Nitrogen, Oxygen and Steam. By Joseph Hilsenrath *et al.* Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 140s.

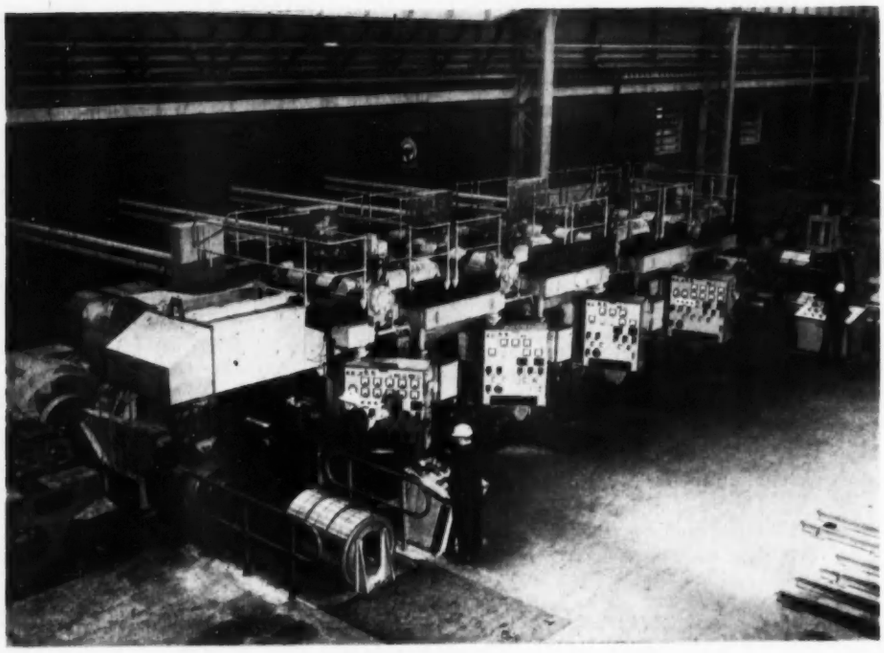
Cold Rolling Mill for Steel Strip at Brinsworth

Following the commissioning, in 1958, of Brinsworth continuous medium-width hot strip mill, Rotherham, the Steel Peech and Tozer branch of the United Steel Companies, Ltd., has brought into operation a cold strip mill on an adjacent site. The cold mill, which takes its raw material from the adjoining hot mill, is of advanced design, and has some novel features.

BRINSWORTH cold mill produces cold rolled low carbon steel strip in a gauge range of 0·010in to 0·160in, and up to 18in wide. Steels of other specifications could be rolled if necessary, the complete plant being suitably designed. Strip can be supplied in any width up to the maximum specified, two slitting lines being provided to deal with the narrow widths such as that used for strapping, and also to carry out edge trimming. As it leaves the main tandem cold mill the strip is in the "hard bright" condition, with a Vickers Pyramid hardness of 200, and it can be supplied in this condition if required. Alternatively, it can be bright annealed to the fully soft condition (V.P.N. 80), or supplied to any specified temper in between.

The adjacent hot mill (which was described in THE ENGINEER, December 19, 1958, page 971) supplies raw material in the form of pickled coils, normally 12in to 14in wide and weighing 25 cwt to 30 cwt. Other sizes of coil can be accepted by the cold mill, which is designed to deal with a range from 6in to 18in wide and up to 2½ tons individual weight. Double-length coils can also be handled; these consist of two normal coils end welded together. They are now being introduced.

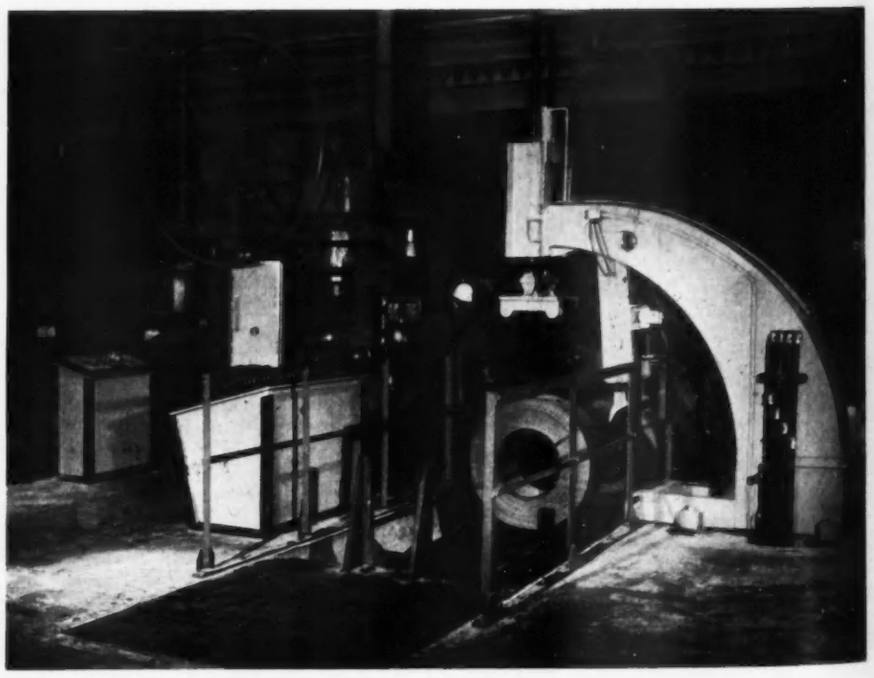
A roadway separates the hot and cold mills, and the hot-rolled coils are sent to the cold mill through a tunnel which terminates in a pit near the first stand of the primary cold mill. From this point coils are lifted by overhead crane and deposited on the feed carriage of the primary mill. Feeding of the coil to the pay-off reel is fully mechanised, and under push-button control by the operator. This equipment opens out the end of the coil for feeding into the first stand of the mill, and traverses the coil on to the pay-off reel.



Four-stand, four-high cold mill, with automatic gauge control

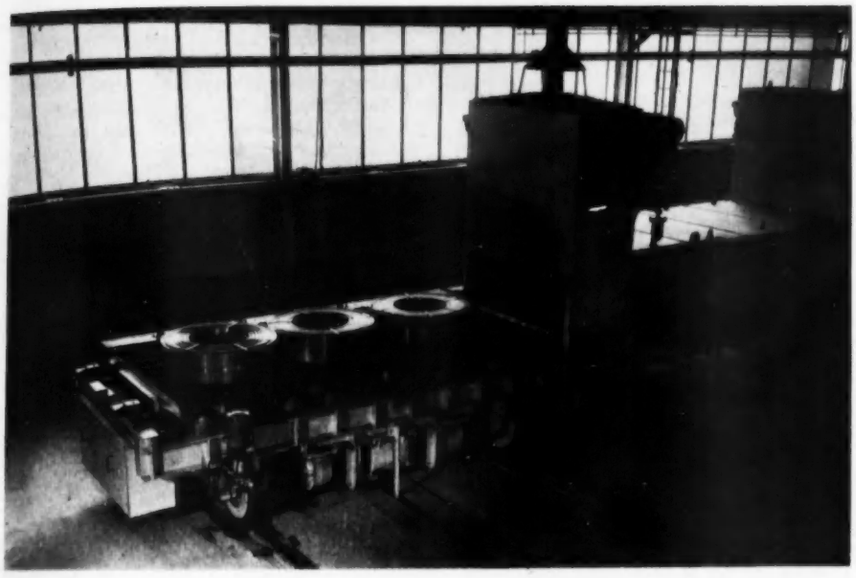
The coils are rolled on a four-stand, four-high, 10½in and 26½in by 22in mill, without guides, the strip being held to its rolling line by means of inter-stand tension which is infinitely variable. Automatic gauge control equipment is built into the mill. Load cells measure the rolling loads in stands 1 and 4, and correct, automatically by means of the roll screw-down, any variation in the gauge which an increase or decrease in load indicates. Stand 1 control evens out variations in the hot-rolled material ready for the major reduction which takes place in stand 2. In stand 4 the final correction to gauge is carried out before the finish-rolled strip emerges and is coiled. To compensate for inter-stand tension variations which may be induced by gauge control, there is automatic tension control between stands 3 and 4. Any deviations from strip straightness are indicated automatically on the stand control panels, thus enabling the operators to make corrections and so ensure that the strip is rolled to very close limits of straightness. At the exit end of the mill equipment similar to that at the entry end enables the rolled strip to be unloaded from the coiler mechanically.

Forged alloy steel rolls are used in all stands, both in the work and back-up positions. The work rolls are 10½in diameter when new, weigh 9 cwt each, have a hardness of 30 to 95 Shore, and can be reground down to 9¾in diameter. On the back-up rolls, which weigh 3 tons each, the "new" diameter is 26½in, and they can be used down to 24in diameter. They have a hardness of 60 Shore. A mobile, hydraulically operated table is used for roll changing, the rolls, complete with chocks and bearings, being set up and dismantled on the table clear of the mill itself. Rolls are ground to a mirror finish on a roll grinder adjoining the roll service and storage bay. Varying degrees of matt finishes can be applied to the rolls by means of shot-blasting equipment when a matt surface is required on the rolled strip.



Two-high temper mill

Fault-finding panel for motor control gear



Coils on annealing furnace charger

One of two slitting lines

The electrical equipment for driving and controlling the mill is notable for the almost complete absence of rotating machinery, except, of course, in the case of the stand driving motors themselves, which have a combined rating of some 4300 h.p. Power for the motors is supplied from combined rectifier/invertor units, which serve the dual purpose of powering the mill motors during acceleration and rolling, and returning power to the supply lines during deceleration. This installation is believed to be the first of its kind in Great Britain. Supervision of the electrical equipment is carried out from a central control desk in the motor room. Any fault occurring during the running of the mill automatically brings into operation an audible and visual warning system, which at the same time shows, by a flashing indicator, the location and nature of the fault.

Strip leaving the tandem mill usually proceeds to the annealing bay adjoining, though it can be sent away in the as-rolled, hard bright condition if required. For annealing, coils are lifted off the mill discharge carriage by overhead crane and placed on an annealing furnace tray, which is held on a tilting table. When three coils, the tray load, are in position, the table is lowered from the vertical to the horizontal position, and the tray is transferred to the annealing furnace bay by means of a powered rail bogey.

There are two identical annealing furnaces, of Nassheur design, arranged in parallel lines, 290ft long. They are heated by coke oven gas piped in from another of the United Steel Companies' works, and are supplied with a nitrogen atmosphere from two adjacent gas plants. The trays are pushed into a gas lock purging zone, and thence into the heating section of the furnace, where a chain-driven conveyor takes over. There are five zones, all automatically controlled, in the heating section, which is 86ft long. At the end of this section the coils pass into a cooling zone, 158ft long, the shell of which is water cooled. The complete annealing cycle takes about twenty-four hours, and the coils emerge through a second gas lock to a transfer point where a powered bogey moves them back into the mill bay.

After annealing, coils pass to the two-high temper mill, which has feeding and discharging equipment identical with that on the tandem mill. The temper mill has rolls 19in diameter by 24in, weighing 1½ tons, and usable by regrinding down to 17½in diameter. This mill is designed to give varying degrees of reduction to produce strip in the intermediate temper range from skin-passed to three-quarters hard. It is in the temper mill that the matt finish is applied, when required, by means of shot-blasted rolls.

From the temper mill, the strip is delivered to the slitting section, where the coils are finally edge-trimmed, and slit to the required width, inside diameter and coil weight. There are two slitting lines, both equipped with feeding and discharging gear similar to that on the tandem and temper mills. On the recoiling heads, however, the slit strips are kept separate by an overarm separator, and stripped to a receiving arm, where they are finally strapped and labelled ready for dispatch. To ensure accuracy of strip width, the slitting heads are assembled as a separate operation, and transferred to the slitting machine for each change of size.

Each coil is tested after every operation according to the properties and surface finish specified for the final product, and for each specification a complete history is

Continuous annealing furnaces showing entry lock and heating zones

kept of the steelmaking, hot rolling and cold rolling procedure.

The main suppliers of plant and equipment were :

Tandem mill and gauge control equipment—Davy and United Engineering Company, Ltd., and Davy and United Instruments, Ltd., Sheffield.

Temper mill.—Sir James Farmer Norton and Co., Ltd., Manchester.

Electrical drives and control gear.—The English Electric Company, Ltd., Stafford.

Roll grinding machine.—The Churchill Machine Tool Company, Ltd., Manchester.

Annealing furnaces.—International Construction Company, Ltd., London.

Slitting machines.—Joshua Bigwood and Son, Ltd., Wolverhampton.

Nitrogen plants.—Incandescent Heat Company, Ltd., Birmingham.

Automatic Profiling of Tube Ends

When preparing tube ends for welding into structures the conventional practice is to make a template of the required profile and use it to mark the tube which is then flame cut by hand. A machine has been developed which, by setting indicators with reference to graduated dials, enables the tube ends for a structure to be automatically flame cut directly from the information provided on drawings giving the centre lines and angles of the main structure. Not only can simple branch tube ends be profiled with this machine, but also the multiple profiles entailed when several tubes have to intersect in a welded structure

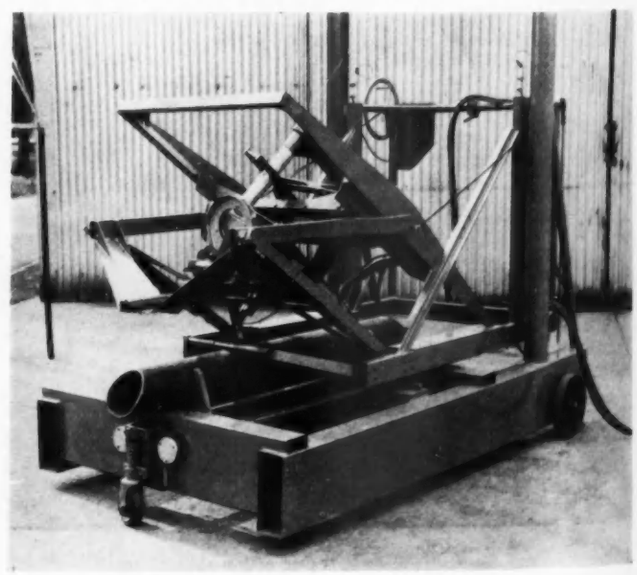
A FLAME cutting machine which, by making simple settings with reference to graduated scales, automatically profiles the ends of branch tubes ready for welding into tubular structures and pipe systems, has been developed by General Precision Systems, Ltd., Aylesbury, Bucks. This machine, operated by semi-skilled labour, eliminates the necessity for the conventional sequence of drawing the required profile, making a template and marking out tube ends for the lengthy process of flame-cutting by hand torch. It effects the accurate profiling of tube ends directly from information provided in the form of drawings giving simply the required centre lines of the tubular assembly ; furthermore multiple profiles resulting from the common intersection of several tubes can also be readily produced.

The prototype machine to this new design, which has undergone extensive trials at the maker's works, can be seen in our illustration, and the first production machines are now under construction. These "Tubefile" machines are designed to handle branch tubes up to 18in external diameter and they can be profiled to saddle barrels (main tubes) of the same external diameter. Profiling can be effected to a lower limit of angle between barrel and branch of 30 deg., and the accuracy of profile attainable is stated to average about $^{1}/_{64}$in. It is pointed out that whilst there is no theoretical bottom limit to the size of tubes which can be handled it would not be considered economical in practice to profile branch tubes of less than 4in diameter on the machine ; there is a practical lower limit of 6in of the barrel tube diameter for which a branch tube profile is cut.

In the simplest case a machine can be set up in well under a minute when the operator is given the angle of intersection of the axes of the barrel and branch, the external diameter of the barrel and the internal diameter of the branch. With this data controls are operated to indicate the appropriate values on each of three scales and then, with the branch in position, the machine is ready for cutting. Other adjustments available can be used to set the required notch angle (the angle formed by the cut on the branch and the surface of the barrel at the point of contact), and offset (in cases when the axes of the barrel and branch do not intersect).

The tube is held stationary in the machine and the cutting head is revolved round it by a supporting pantograph system with a drive transmitted from a circular rack. The cutting head speed can be adjusted as required and during actual cutting in respect to a varying thickness of metal. Normally cuts are made alternately clockwise and anticlockwise to avoid twisting and damage to the flexible tubes carrying the gases to the cutting head. Regulating valve gear for the gas supplies is mounted on the front of the machine so that it has only to be connected to normal oxygen and acetylene supplies. The electrical load of the control and operating motors total about 1kW.

The machine is built up on a heavy fabricated base frame which can be fitted with wheels to enable the plant to be moved round a shop if required. Transverse members at the rear and centre of the base have inset ball castors along which tubes can be easily moved sideways in and out of the machine and forwards into the cutting position. When a tube has been positioned, operation of a hand lever at the side of the machine actuates jaws which close on the tube to centre it accurately and lock it ready for cutting. These jaws when not in use retract below the level of the support castors and, irrespective of tube diameter, they automatically centre the axis of the tube along the centre line of the machine.



Rear of tube end profiling machine showing how cross bar of "halving" frame registers on tube to set cutter head in respect to the tube axis

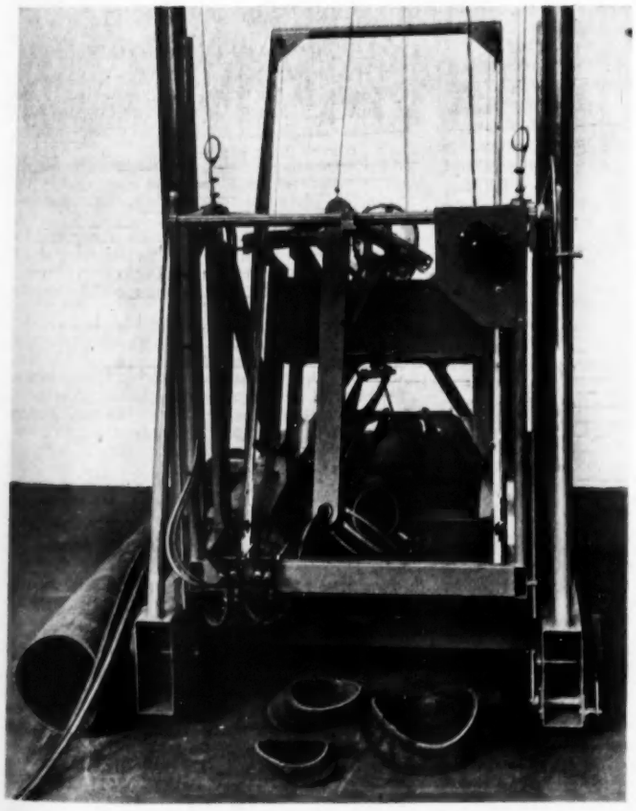
The profiling mechanism is carried on a lever system incorporated in a frame structure, which moves vertically in slides on pillars extending up from the base. The weight of this frame is counterbalanced so that the complete assembly can be raised clear of the base without effort for inserting or removing tubes. When this assembly is lowered on to the tube centred and clamped in the jaws the rear cross bar of what is termed a "halving" frame contacts the top of the tube. Through its side members this halving frame is pivoted at the centre to the sides of the profiling frame and hinged at the bottom to the main base frame.

As the cross bar is held up on contact with the top of the tube whilst the profiling assembly is lowered the halving frame pivots and automatically controls the level of the profiling frame to set the operative position of the cutter head arm in respect to the axis of the tube irrespective of its diameter.

With the tube thus positioned the desired angle of intersection of branch and barrel for which the tube end is to be flame cut is set by tilting the profiling assembly by the operation of a wheel with reference to a graduated quadrant. The system is then set in accordance with the external diameter of the barrel by another graduated hand wheel. Finally, an inching switch is operated to indicate on a scale the internal diameter of the branch tube. If the branch is to be offset on the barrel the amount of required offset is set by turning a screw to move the head assembly over that length.

The machine settings having been completed, the gas valves at the front are then used to initiate first the preheating and then cutting flame. When the cutting flame has been initiated a start button is depressed and the cutter travel round the tube profile begins. A speed control knob is used during cutting to give the optimum cutting speed in accordance with variations in metal thickness round a profile. In the event of cutting being interrupted at any point a push button can be depressed to return the cutter arm to that point for the cut to be resumed. When the cutting head has been rotated through a full circle it is stopped and, after the machine has been unloaded and another tube inserted, the next cutting sequence is carried out with the head rotating in the opposite direction.

When it is required to cut "multiple" profiles the first profile is cut and the tube rotated about its axis and, after the settings have been made in accordance with the required change of angle, &c., the subsequent superimposed profiles can be machined on the prepared tube end. The maker points out that when large quantities of tubes have to be profiled at both ends two machines can be spaced apart to accommodate the maximum length between the tube ends. One end of each tube is cut on the first machine and the datum line and reference point marked on it. Each tube is then transferred sideways to the next machine for its opposite end to be profiled in accordance with the datum and reference markings.



Branch tube end being profile flame cut: the fork-ended member of the parallelogram linkage rotates about the axis of the barrel

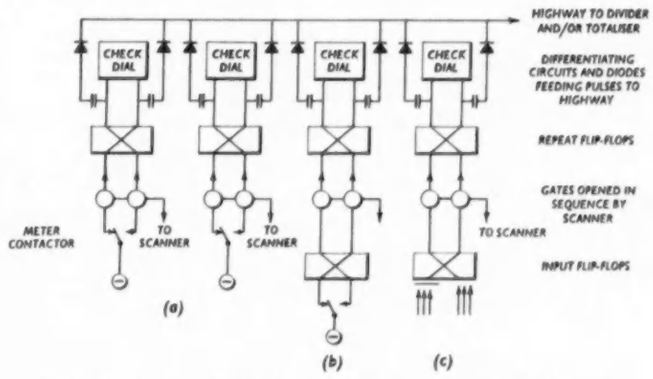
Electronic Summation Metering Equipment

ELECTRONIC summation metering equipment, for use in power stations and bulk supply points for electricity, has been developed by Ferranti, Ltd., Hollinwood, Lancs. The main innovation is that summation is effected by electronic means (as described below) instead of electro-mechanically. This development results in considerable saving of space and simplification of maintenance. But although the new electronic "summation" may eventually supersede its electro-mechanical counterpart both kinds of equipment are compatible; the electronic summator can drive electro-mechanical equipment and vice versa.

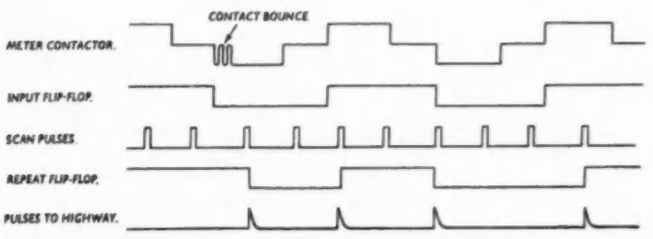
The function of the summator is to register incoming pulses from a number of channels, on check dials and to integrate these pulses on another register. It can handle coincident pulses on any or all of the channels and, as the pulses transmitted by a contacting device may be subject to contact bounce, the summator is designed to disregard any spurious pulses.

Briefly, the summator stores incoming pulses, coincident or otherwise, from a number of channels (up to sixteen) on display registers and totals all the pulses on a totalising binary register. Incoming pulses, which are stored in transistor flip-flops as binary digits, are passed on sequentially to a second set of flip-flops actuating an impulse-driven stepping motor, which advances one step on each reversal of current drive. These reversing impulses produce a forward step-by-step rotation of the rotor and through gearing indicate the kilowatt-hour registration on the dials. The outputs from the final flip-flops are differentiated and fed into a common highway in sequence to a totalising register.

In the electronic summator a number of change-over switches are gated on each side by a sequential scanner, the outputs from the gates operating a bi-stable flip-flop. Thus a change in sense of the switch will cause the flip-flop to change state (or be "set"), on the arrival of the succeeding scanning pulse, and will be "reset" only after a further change in sense of the switch at the appropriate scan period. An impulse driven stepping motor (which advances one digit on each reversal of current drive) having a centre tapped energising coil, functions as the load of the flip-flop. Thus each pulse from the meter is registered in the check dial. Furthermore the output of the flip-flop is differentiated (and rectified to produce unidirectional positive pulses) and transferred into a common highway to a totalising register. As a flip-flop can change state only when being scanned, the highway pulses will



(*a*) Simple scheme. (*b*) With input flip-flop. (*c*) With photo-electric input.



Figs. 1 and 2—Electronic summation metering.

appear in time sequence. The totalising register consists of a binary counter, the load being the two halves of a stepping motor coil. Thus each pulse injected in the highway causes a change in state of the binary counter, and with it a record of pulses on the dials (see Fig. 1(*a*)).

Thus pulses are transferred into the highway only during scan pulse periods, and the rate of impulsing of the totaliser motor is equal to the scan frequency multiplied by number of channels (scan frequency being defined as rate at which a particular channel is sampled).

The simplified system as described would require the impulse sending contacts to remain closed for an appreciable time, in particular during sampling, or alternatively, an extremely high scanning rate, to ensure that incoming pulses are gated. This disability is avoided by initially storing the state of the change-over switch in a further bi-stable circuit, and then gating the outputs of this bi-stable store by the scanner (Fig. 1(*b*)).

Coincident pulses, like any others, would be stored in the input flip-flops and sequentially scanned. By its nature, a double sensing system eliminates the effects of contact bounce ; the flip-flop merely sets itself on the first make, ignoring subsequent rebounds, and resets only on a change in sense of the impulsing switch.

Sequential scanning is performed by decoding the outputs of a cascade of binary dividers, driven by a master multivibrator making a maximum of sixteen states.

The decoders and the gates as shown in the simplified schematic are combined in a single circuit. Thus, at any particular state of the binaries, one only of the sixteen channels is selected. However, there is still the possibility of adjacent scan pulse edges coinciding with the incoming pulse edges on both channels, in which case the totalising binary register would be unable to resolve them as two separate pulses. Therefore the decoding arrangement has virtually five binary dividers in cascade, the alternate states, sixteen in all, being decoded. Thus one clear pulse width exists between adjacent scan pulses, eliminating the chance of unresolved pulses being lost (Fig. 2).

The scanner is analogous to a rotating switch having sixteen contacts, with a clear break before make. It will be seen that the highway pulse rate will be sixteen times the scan frequency where two channels are adjacently placed. Division of the highway pulses by a suitable ratio may be necessary in many instances to keep within the limits of the totalising motor.

Where other forms of impulse senders are used, for example, photo-electric, further simplification is possible (Fig. 1(c)). A double-sensing photo-electric switch consisting of two photo-transistors in a bi-stable flip-flop configuration, can replace both the mechanical contacting switch and the initial flip-flop. The photo-transistor flip-flop is triggered from one stable state to another by exposing each photo-transistor in sequence to a light source by means of a pair of rotating shutters, adequate margins prohibiting simultaneous exposure of both. Light bounce is of no consequence in a flip-flop, as mentioned previously.

Where it is necessary to indicate net power (i.e. negative channels), this facility can also be provided by electronic means. The circuit consists of a reversible binary counter with a store capacity of four or more, and associated logical gating. The reversible counter is itself a device that can increase its contents by one (counting in a positive sense) or decrease it by one (counting in a negative sense) depending upon which of its inputs is pulsed. The two highways, " generated power " and " auxiliary power," for example, feed each of the two inputs. Under normal loading conditions the generator pulses, which come at a higher rate, are routed to a " net-generated " register by means of gates operated by the reversible counter. Under light load where the reverse situation may take place for short periods, incoming auxiliary pulses will be held in store, until subsequent generator pulses cancel them, after which the generator pulses are routed once more to its net register. Should the auxiliary pulses fill the store further pulses may be routed to a net auxiliary register if desired. The gross totals could be recorded if required.

The entire summator is transistorised, all the circuit functions being provided in printed card form. The whole is contained in a case measuring 23in by 12in by 11in which includes the printed card container at the rear, with the register dials situated in front. These dials are mounted on hinged plates to permit each access to the cards. A total of eighteen registers can be fitted on the panels, and where fewer channels are used, a maximum-demand indicator can also be accommodated. Much of the back wiring on the

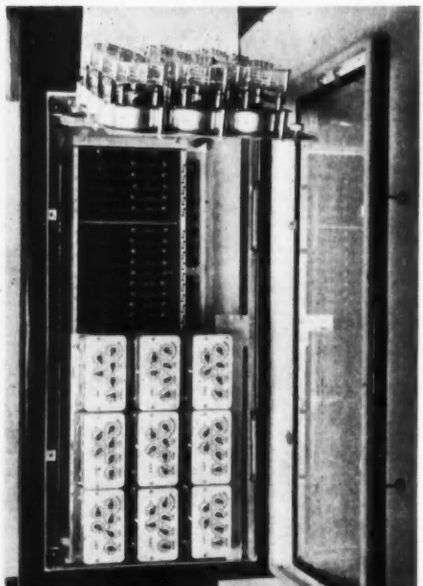


Fig. 3—Electronic equipment for summation metering in power stations and substations. The transistorised " summator " contains up to eighteen display registers (sixteen inputs, one totaliser and one spare)

card container is printed. The summator lends itself very easily to any subsequent re-arrangement or additions to existing schemes, selector points having been provided for a variety of division ratios and scanning ratios. A further facility is the addition of sub-totals from two highways on to a totalising register, and finally outputs to " printometers " are also included.

The increased rate of impulsing now possible enables smaller units of power to be transmitted more often, making for better accuracy of final reading. The absence of ratchets in the stepping motors helps to reduce wear. Furthermore, the transistors, used as they are in the switching mode, dissipate negligible power ; a typical sixteen channel summator uses only 15W, of which more than half is dissipated in the motors.

Since no ventilation is needed for cooling, dust can be kept out of the cabinet. The components used on the printed cards are Services-approved and are considerably underrated. The cards and their respective socket locations are colour-coded to simplify insertion. Servicing, when necessary, is simply a matter of replacing a faulty card or motor and a terminal on the latter makes replacement easy.

TRANSPARENT PLASTICS FILM.—A new plant for the manufacture of transparent polythene film by the " chill cast " method is now in full production at the works of Peter Dixon and Son, Ltd., 11, Fetter Lane, London, E.C.4. This method was developed in the United States some two years ago and instead of using the conventional blowing process it is based upon the extrusion of a film which is quickly and under pressure control-cooled and set on rolls. The selected materials and polymer used at the Dixon works, combined with special production techniques, allow the manufacture of a film of very high strength to gauge ratio, the gauge of the film being consistent in both the transverse and longitudinal directions. The film has an unusually high degree of transparency and the true colours of goods packed in it are clearly visible. This " Dixopak " film, as it is known, is available in rolls up to 36in wide and in thicknesses from 0·001in to 0·005in.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

BOLTS AND NUTS FOR AIRCRAFT (GENERAL CLAUSES)

No. A.100 : 1960. Price 10s. The preparation of this new British Standard was originally undertaken with the aim of bringing together in one document requirements common to " A " series British Standards for aircraft bolts and nuts. The Technical Committee which drafted the standard decided, however, to incorporate additional requirements for the inspection of the bolts and nuts, with particular reference to their freedom from material defects. The standard is intended for use in conjunction with individual standards for aircraft bolts and nuts in which conformity to the requirements of A.100 is a specific requirement.

The specification is composed of two parts, the first containing general requirements applicable to all bolts and nuts, and the second specifying inspection procedure. The second part is in four sections. Section One relates to all bolts and nuts ; Section Two states the requirements of freedom from material defects ; Section Three stipulates the additional requirements for cold or hot-forged steel bolts having a specified maximum tensile strength of not more than 65 tons per square inch ; and Section Four deals with additional requirements for cold-forged aluminium alloy bolts.

An appendix gives details of the Unified thread identification features applicable to aircraft bolts and nuts.

CONNECTORS FOR TIMBER

No. 1579 : 1960. Price 6s. This standard (first published in 1949) has been revised under the authority of the Timber Industry Standards Committee and the principal changes in the specification are the reinstatement of the malleable cast-iron shear-plate connectors, the elimination of corrugated toothed-ring connectors and a modification of the shape of the teeth in the round toothed-plate connectors.

To reduce the possibility of confusion resulting from reference to connectors by table numbers, each type of connector has been allotted a number and the size and sub-type are indicated by a suffix. A list of connector numbers is given in an appendix. Dimensions and materials of the connectors are covered, but data on the strength properties of joints made with the connectors are not included. British Standard Code of Practice, C.P.112, " The Structural Use of Timber in Buildings," contains such data relating to those connectors which are in accordance with this standard and on which authenticated tests have been carried out.

GEAR PLANING AND SHAPING MACHINES

No. 3329 : 1961. Price 12s. 6d. This specification—requested by the Admiralty—establishes much-needed standards of accuracy for two classes of machines : those for cutting high precision gears and those for cutting general purpose gears.

One clause relating to inspection and testing requires that test methods shall be those prescribed by the National Engineering Laboratory, East Kilbride, near Glasgow, or such others as may be agreed between the manufacturing and the inspecting authority. It also states : " The purchaser or his representative, or the agreed inspecting authority, shall be granted facilities for carrying out or witnessing any or all of the tests."

Although particular test methods are not specified, appendices in the publication contain suitable methods for verifying the alignment and concentricity of work spindle and cutter and for checking the uniformity of motion of the work spindle relative to the cutter. For quick reference, a summary of permissible errors is also given in an appendix and other appendices give recommended methods for stress relief annealing of iron castings and welded parts and for heat-treatment of lead screws.

CARBON STEEL PIPE FLANGES (OVER 24IN NOMINAL SIZE) FOR THE PETROLEUM INDUSTRY

No. 3293 : 1960. Price 12s. 6d. This standard specifies materials, dimensions and marking for forged carbon steel slip-on welding and welding neck flanges, of nominal sizes 26in to 48in. Similar types of flanges of nominal sizes up to and including 24in are covered by B.S.1560. Care has been taken in the preparation of the standard to ensure interchangeability between British and American made flanges. At present there is no national American standard for steel flanges in this size range. The dimensions given in B.S.3293 are, however, on the whole in accordance with the standard practice of the American Manufacturers' Standardisation Society of the Valve and Fittings Industry and with those dimensions currently adopted by the principal American flange makers.

SHORTER REPORTS

Naval Architects' Annual Dinner

VISCOUNT Runciman, the President, was in the chair at the annual dinner of the Royal Institution of Naval Architects which was held at Grosvenor House, London, on March 28, and was attended by over 1000 members and their guests. The Lord Mayor of London, Alderman Sir Bernard Waley-Cohen, proposed the toast of "The Royal Institution of Naval Architects" and commented on the responsibility of the naval architect to avoid making mistakes since these could not be corrected at sea. He went on to say that Great Britain had been in the front of ship design for many years and that a large part of the nation's prosperity was dependent on its shipping.

The President responded and said that this was not an easy time for naval architects and shipbuilders and that as long as world shipping capacity remained in excess of requirements there would be problems calling for the very best design in order to survive with profit. To solve problems, naval architects have to translate and apply the results of research, and Viscount Runciman commented that if they had as much money for research as aircraft, there would be no lack of projects on which to spend it. He was of the opinion that there was no immediate prospect of a break-through, not even with nuclear power, unless something much more efficient than a propeller for propulsion was forthcoming. Research into production techniques could help the shipbuilding industry to improve itself, but any advance would be marginal. The President quoted from a paper entitled, "Britain's Deep Sea Liner Trade 1945–1951," by Basil Sanderson, and presented before the 1952 Spring meeting, the reference relating to the waste of effort in raising of cargo from the quayside and subsequently lowering a similar distance into a ship's hold. He continued by stating that on the North Atlantic run the cost of loading and unloading cargo exceeded all the combined costs of operating the ship and thought that here was an opportunity for research to effect considerable savings. The problem embraced many factors, covering as it did port design and operation, the manufacture and packaging of goods and the design and construction of ships to permit horizontal as opposed to vertical loading, but, he felt, it must be solved. Viscount Runciman combined his reply with proposing the toast of "The Guests", on whose behalf Sir John Lang responded.

Electronic Instrumentation for Nuclear Power Stations

A SYMPOSIUM on electronic instrumentation for nuclear power stations was held in London last week, under the auspices of the British Institution of Radio Engineers.* The symposium was divided into two sessions. In the first session five papers, concerned with instrumentation systems applied to four specific nuclear power stations, were discussed. The second session was concerned with circuit techniques and five papers were presented for discussion.

After a short introduction by the chairman the symposium began with a paper by R. D. Trotter (Central Electricity Generating Board) dealing with background factors affecting the design of control equipment for the civil nuclear power stations. It is intended that the first nuclear power stations should operate at very high load factors, as base load stations. Accordingly, the stations will have a central control room layout, designed to use the minimum of staff on day-to-day operation.

In the second paper R. E. B. Dawson and M. W. Jerins (the Nuclear Power Group) described the instrumentation at Berkeley nuclear power station. Here neutron-flux instrumentation is used for reactor power measurement and for operating safety trips if the power is raised too quickly or beyond a preset maximum level.

At higher powers, control and protection is based on temperature measurements, about 1000 thermocouples in each reactor being installed to measure fuel element, channel gas, graphite and other temperatures. Selected fuel element temperatures can shut down the reactor, others being recorded by an extensive system of multi-point 10in recorders and automatic loggers.

The shut-down initiating devices are triplicated and fed into a safety system which shuts down the reactor only if at least two out of the three give a trip signal. This reduces the possibility of spurious reactor trips caused by failure of the trip devices, which are designed to fail safe.

The system of faulty fuel element detection employs an automatic logger which computes averages so giving discrimination between random and significant rises in carbon dioxide gas activity, indicative of defective fuel elements. The automatic logging also relieves the operator to a large extent of the burden of examining the large number of graphical records and gives a degree of data reduction.

Equipment is also provided for the detection of leaks between steam and carbon dioxide circuits: in addition radiation and activity in and around the station is monitored. Gas and steam flows are measured and the data transmitted by a pneumatic system.

The display equipment for the major instrumentation is centralised in or near the station control room. Instrumentation on vertical panels is provided for long term recording and control, whilst the minute to minute operation is effected from the control desk.

Reactor instrumentation at Bradwell (Essex) and Latina (Italy) nuclear power stations was described in a paper by R. V. Ingham (the Nuclear Power Group). In particular the author referred to venturi-type measurements in the coolant gas circuit to supervise the maintenance of adequate gas flow; he also described the system adopted to confirm the integrity of the pressure circuit.

Temperature scanning equipment at Hinkley Point nuclear power station was the subject of the next paper, by R. I. Ostler and J. M. Tyrill (Marconi Instruments, Ltd.). The equipment, which was described in some detail, is a data handling system with magnetic drum storage. Temperatures of the graphite, fuel elements, and outlet gas, as measured by thermocouples are scanned and the remainder of the 720 input positions in the drum are used for self checking routines. It is a high-speed system, taking 144 seconds for a complete scan. There is a memory of twenty scans, representing forty-eight minutes. The long life and extreme reliability of input switching required is achieved by using reed relays driven by transistors in a matrix arrangement. The equipment is unusual in that analogue to digital conversion is performed directly on the outputs of the thermocouples. Since the converter has a high input impedance it does not affect other equipment, e.g. pen recorder, in parallel with it. A circuit has been developed to linearise thermo-couple signals so that the output is in deg. Cent. instead of thermocouple electromotive force. The magnetic drum storage and arithmetic circuits employ conventional medium speed computing techniques. Readout is on strip printers, a typewriter and a tape punch. The latter is used when a reactor trip occurs, to record a complete back log. The operating range of the equipment is from 0 to 700 deg. Cent., the long-term overall accuracy (excluding thermocouple variations) being ± 3 deg. Cent.

In the fifth paper P. J. Kealey (Marconi Instruments, Ltd.) described the instrumentation used at Hinkley Point for the measurement of neutron flux with particular emphasis on the method of operational testing of the various measurement channels.

A d.c. system of measurement is used throughout the entire range from start-up to full power. The use of a large installed neutron source together with gamma compensated ion chambers obviates the need for pulse counters at very low power levels. The completely d.c. system results in simplified instrumentation, simplified operational testing, and reduction in types of instruments held as spares.

Instrument cubicles contain built-in test systems such that operational or day-to-day testing can be carried out by one person without the use of portable test gear. Remotely situated head amplifiers are included in this test, necessitating the use of high insulation relays for switching input currents as low as 50×10^{-12}A.

At the second session of the symposium, five papers on circuit techniques were presented. Shutdown and thermocouple trip amplifiers were described by J. Hazell (General Radiological, Ltd.), and G. G. Ballard (Elliott Nucleonics, Ltd.) respectively. The shutdown amplifier takes a signal from an ionisation chamber and from it produces a voltage proportional to reactor power. A second voltage from a neon stabiliser serves as a reference, and the two are fed alternately into a differential amplifier. The amplifier output passes to a phase discriminator and a polarised relay, the latter being energised only in safe reactor conditions. Continuous monitoring of the reference is provided, and a rise in voltage is arranged to trip the amplifier. In the thermocouple trip amplifier the signal input from the thermocouple is similarly backed off against a preset reference. In order to meet fail-safe requirements an a.c. carrier technique with transistor modulator is used.

A general survey of the use of transistors for reaction instrumentation was given by E. P. Fowler (Atomic Energy Establishment). The low voltage and low power characteristics of these devices point to long life, although this still has to be proved in practice. A beginning was made with health and monitoring applications, but now that transistors with higher cut-off frequencies are available it is possible to make transistorised instruments comparable in their performance with the best valve equipments. Some valves (e.g. electrometer valves) will always be needed, and great attention is being paid to the reliability of such valves for use in transistor circuits. Transistors make circuits simpler as well as less bulky, and are very flexible in their circuit requirements. Three transistorised instruments were described in which the ability to operate on a centre-tapped 50V d.c. source has eased the provision of standby power.

A paper on the design of a pulse counting instrument for measurement of neutron flux was presented by R. B. Stephens and J. N. Evison (Mullard) Ltd.) and E. P. Fowler (Atomic Energy Establishment). The use of transistors enables a complete pulse counting channel to be housed in one box, as compared with a 6ft rack required for a previous valve equipment. The final paper of the symposium, by A. A. Luckow (Marconi Instruments, Ltd.), described a gamma radiation monitor in which the combination of ionisation chamber and d.c. chopper amplifier enables radiation dose rates to be read in the range of 0·1 to 100mR/hour.

Refrigeration and Air Conditioning Exhibition

THE second International Refrigeration and Air Conditioning Exhibition and Convention will be held at Earls Court, London, from Tuesday, April 11, to Friday, April 14, and will be officially opened by Lord Mancroft at 11 a.m. on the Tuesday.

* The proceedings of the symposium will be published in the Journal of the Institution.

SHORTER REPORTS *(Continued)*

Post Office Telecommunications

In a White Paper, "Post Office Prospects" (Cmd. 1327, H.M. Stationery Office, Price 6d.), published on March 29, it is stated that during the year about 100 of the remaining 820 manual telephone exchanges will be converted to automatic working. By March next year about 300 exchanges, serving 1,250,000 subscribers, will have subscriber trunk dialling facilities. Tests will begin by the autumn on the first electronic telephone exchange at Highgate Wood, London.

Trunk traffic has increased annually by an average of 10 per cent over the last three years. The number of trunk circuits to handle this rapidly growing traffic is expected to increase from about 29,300 to 33,400 in 1961–62. In 1961–62 1500 new Telex lines will be added to the existing 7000.

The new telephone cable to Canada (CANTAT) will be brought into service in the autumn (see our March 31 issue). Manufacture of an additional trans-Atlantic telephone cable to link this country and the U.S.A. will start during the year. The cable is likely to be laid in 1963. The first telephone cable between the United Kingdom and Iceland will be laid in the autumn.

Experimental tests of satellite communications across the Atlantic, in co-operation with the U.S.A,, will start in 1962, and the Post Office will provide a ground station in this country.

Power-Driven Earth Auger

A portable power-driven earth auger designed to bore holes up to 10in diameter and 2ft 6in deep which is marketed by the Earth Boring Machine Company, Lake Works, Porchester, Hants, is illustrated below. The machine is driven by a two-stroke 2½ h.p., air cooled, petrol engine through a gearbox giving a 17½ to 1 reduction. The augers are rotated at up to 200 r.p.m. and the engine throttle control is mounted at an accessible point on the tubular support frame through which the operator controls the machine. An automatic centrifugal clutch is designed to disengage at idling speed and pick up the load as the throttle is opened.

Augers from 2in to 10in diameter are available for use with the borer and their standard length of 30in can be increased for deep boring by the fitting of 15in long extension shafts. Without the auger the machine weighs only 29 lb so that it can be readily handled by one operator. A two-operator machine for use with augers 14in in diameter is also available.

[Reply Card No. E5602]

Portable power-driven auger for boring holes 10in diameter to a depth of 30in in the earth

Re-fuelling Machine for A.G.R. Windscale

Our illustration shows the refuelling machine which is being built by Markham and Co., Ltd., Chesterfield, for the U.K.A.E.A. Advanced Gas Cooled Reactor at Windscale. This machine was designed by John Brown (S.E.N.D.), Ltd. (as main contractor) in conjunction with the United Kingdom Atomic Energy Authority.

The main function of the machine is to refuel the reactor while it is under full load and gas pressure. Briefly, the machine, which is 65ft high and weighs about 400 tons, consists of a crab and gantry supporting two pressure vessels. One pressure vessel is for the normal process of refuelling by discharging and charging fuel elements ; the other is for handling broken or damaged fuel elements. Both pressure vessels are shielded against gamma radiation by a radial thickness of 22in of cast iron, and against fast neutrons by a radial thickness of 9in of densified wood laminate.

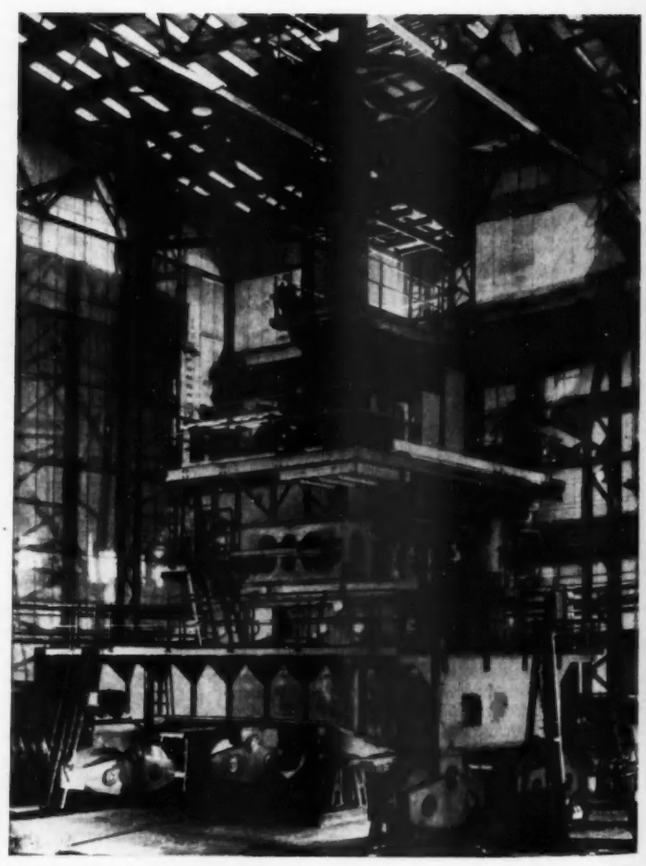
The pressure vessel for the normal charge and discharge operations is 21in in diameter and contains a rotating magazine which has three compartments : one is for storing an irradiated fuel element ; the second is for storing a new fuel element ; and the third is for housing a stand-by seal plug.

The machine is self-contained and is equipped with independent electrical drives for longitudinal and cross traverse motions. Accordingly, the retractable nose unit which extends below each pressure vessel can be positioned accurately over any one of 253 reactor charge tubes in preparation for refuelling. To ensure precise location of the 60ft vertical pressure vessels extreme accuracy in positioning is required—a tolerance of ±0·005 in the final position is specified and we understand that even closer accuracy was attained during recent tests when the machine was erected in the maker's works at Chesterfield. Accurate positioning is achieved automatically with the help of a group of electrical sensing devices carried on the nose piece. There is a pair of sensing elements for each of the two travel motions—longitudinal and cross traverse. Each pair of sensing elements operates through a servo system to feed back error data to the appropriate drive on approaching the required final position of the nose unit. The effect is that the speed of the drive is reduced progressively as the error diminishes. Eventually on approaching to about 0·005in of the required position a final creep speed of about 0·001in in ten seconds is achieved, so that the final positioning is effected without overshoot.

With the machine accurately positioned, the refuelling operation is started by making a manual connection between the machine and the fuel plug string. Then the nose unit is extended downwards from the handling vessel to connect with the selected charge tube and make a pressure-tight seal. The spent plug string is then slowly hoisted by an electro-mechanical drive into the appropriate compartment of the three-position magazine. Next the magazine is rotated and a new plug string is lowered and locked into the reactor.

To ensure continuous cooling of the spent fuel elements until they have been disposed of, the refuelling machine is equipped with an independent cooling system. The normal-handling pressure vessel and the cooling system both have a design pressure of 500 lb per square inch, the design temperature is generally 325 deg. Cent., but is 400 deg. Cent. for some parts.

All the electrical and mechanical operational controls are installed on the machine itself. There is provision for using closed-circuit television to view some of the operations inside the normal or special handling vessels.



Works assembly of refuelling machine for Advanced Gas-Cooled Reactor at Windscale

Rubber Bolster Press

A HYDRAULICALLY-OPERATED rubber bolster press which has been designed and built by Boulton Paul Aircraft, Ltd., Wolverhampton, is capable of exerting pressures variable up to 5000 lb per square inch and can accommodate work within a 60in diameter envelope. In this machine, to be seen in the illustration, below pressurised hydraulic fluid contained in the upper part of the dome shaped chamber forces the work piece into the die.

The main structure of the press comprises two tubular side columns rigidly coupling a heavy base beam to a bridge member. The dome is guided in slideways on the columns and at its top is coupled through a universal joint to the piston of the main hydraulic ram housed in the bridge. A beam fixed to and extending across the dome has slippers at each end. These slippers register in the pillar slideways to guide the dome and are connected by tie-bars to slippers at the lower end of the dome to ensure that its alignment is maintained. Hydraulic damping cylinders at each end of the dome beam are connected to the bridge and provide a means for controlling the speed at which the dome is raised and lowered.

The chamber within the dome is, part way down its length, fitted with the rubber diaphragm and the sealed upper compartment thus formed is filled with an hydraulic fluid. A hemispherical block fitted in the top of the compartment to reduce the volume of hydraulic fluid serves to decrease the pressurisation time—thereby reducing the operational cycle. The internal diameter of the open skirt below the diaphragm is machined to a clearance fit over the cylindrical platen of the press. Dies may be accommodated both on the top face of this platen and, by the removal of the special filling block within the recessed platen, deeper dies can be used. The maximum depth of draw available is dependent upon the type of pressing required and is of the order of 15in.

A groove machined round the lower end of the inside of the skirt aligns with a groove round the lower side of the platen when the press is closed. This platen groove contains a series of keys which are moved outwards by eccentrics when a gear ring is turned by an hydraulically operated pinion in the press base. These keys lock the dome to the platen for the pressing operation and thus all the reactions are taken within the assembly; this design afford a considerable reduction in the overall weight of the external press structure. The platen assembly is mounted on slideways so that it can be moved out of the press for the loading and unloading of work. If required these ways can be extended on both sides of the press to enable the dies to be loaded and unloaded on one side whilst the other is in the operative position under the dome. The platens are automatically aligned in the frame before a pressing operation can start.

The press operates on an automatic cycle—the dome is lowered and locked, hydraulic fluid stored in reservoirs is then pumped via a manifold into the pressure chamber of the dome to displace the diaphragm and shape the work on the die. The pressure available for this operation is variable up to 2000 lb per square inch. When, however, greater pressures are required an intensifier system is introduced into the automatic sequence to give working pressures of up to 5000 lb per square inch.

[Reply Card No. E5611]

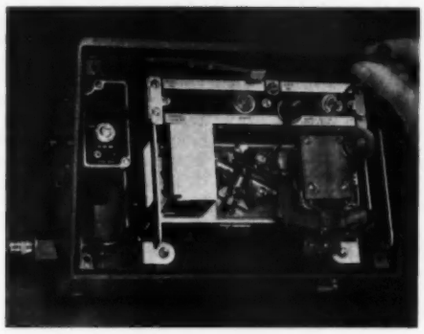
Hydraulically-operated rubber bolster press with a capacity for pressures up to 5000 lb per square inch and accommodating work with a 60in diameter enclosure

Two-Wire Control and Telemetry

IN a d.c. monitoring and control system now being marketed by Honeywell Controls, Ltd., Greenford, Middlesex, a 42V d.c. source is modulated by the conditions in the system to provide indications and control signals. The central element of this "Electrik Tel-O-Set" system is a recorder-controller, which provides the d.c. supply from an a.c. mains input and is connected by two unscreened wires to the field units, consisting typically of a transmitter and a valve operator. The field units need no local power supply. A typical unit is the PP/1 process pressure-to-current transmitter. An oscillator is connected across the d.c. line and acts as a variable resistance when its frequency is changed, so as to modulate the current in the line circuit. Process pressure is connected directly to a Bourdon tube or bellows assembly, the deflection of which is applied to a force-balance beam so as to vary the gap in a ferrite detector head. Movements of the detector cause changes of inductance in the oscillator circuit and hence vary the line current over the range 4mA to 20mA. A transmitter operating on those principles is illustrated.

Operation of the recorder-controller is similar. The varying signal is applied to a magnet unit and deflects a force-balance beam. A ferrite detector with its moving element attached to the beam varies the frequency of an oscillator, the output of which is applied to a torque motor operating a recorder pen, and to a bridge circuit from which an error signal output is derived. The error signal is fed to a controller which uses conventional circuits to obtain proportional, reset and rate control actions. Controller output is the standard 4mA to 20mA d.c. line signal.

The final control element is a valve operator, positioner, or self-contained electro-hydraulic actuator. In the case of the valve operator, deflection of the force-balance beam by the signal from the controller causes it to act as a flapper in relation to the nozzle of a pilot relay and vary the output pressure of the relay between 3 lb and 15 lb per square inch.



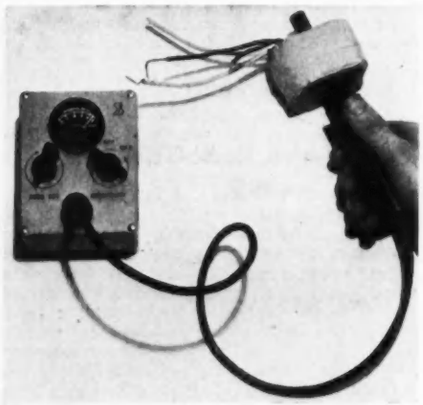
Process pressure-to-current converter/transmitter unit of two-wire d.c. control and recording system, showing process air connection (left) and components of detector system

Separate transducers operating on the principles described are available for linking pneumatic systems electrically and avoiding the lags introduced by lengthy runs of pneumatic tubing. Units of the system are transistorised and will operate in ambient temperatures of −40 deg. to +150 deg. Fah. Equipment of this kind is being supplied for the 720-mile northern pipeline of Oil India Private, Ltd.

[Reply Card No. E5612]

Shorted Turn Detector

WE have received from the Nuclear Energy Division of Spembly, Ltd., Chatham, particulars of a shorted turn detector intended for the test departments of manufacturers of components such as transformers, chokes, solenoids and tuning coils. This portable instrument consists of a small oscillator unit containing transistor circuits for shorted turn sensing, an indicating meter, set zero, on/off, and sensitivity controls, and the power supply (a standard 4·5V battery). Into the front of this unit is plugged one of a range of three hand probes designed to suit the range of coil sizes normally encountered. Overall dimensions of the oscillator unit are 4·75in by 3·75in by 2·75in. As seen in the illustration, tests are performed by inserting a suitable probe within the bobbin or coil former, no connection to the windings of the coil under test being required.



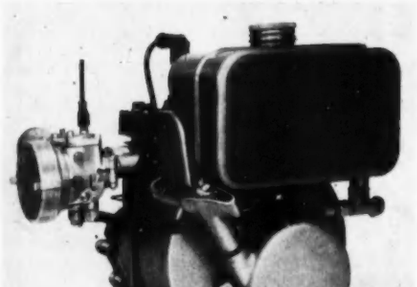
Control unit and probe of transistor oscillator device for detecting shorted turns in small components

[Reply Card No. E5613]

SHORTER REPORTS *(continued)*

Light-Alloy Engines

A RANGE of petrol engines constructed largely of light-alloy pressure die castings is to be produced by the Villiers Engineering Company, Ltd., Marston Road, Wolverhampton, for agricultural and industrial purposes; it will include engines with vertical and horizontal crankshafts, ranging from 50 c.c. to 150 c.c. and from ¾ to 3½ b.h.p. The only example in production is a 50 c.c. unit rated at 0·92 b.h.p. at 4000 r.p.m., a brake mean effective pressure of 60 lb per square inch; no fuel consumption is quoted. This engine is seen in our illustration;



Particular compactness is claimed for these side-valve engines. Notice that the cooling air passes from the inlet to the exhaust side of the head

it is a side-valve design with the unusual proportions of bore, 43mm, and stroke, 34mm. There is a cast iron cylinder liner and nickel-alloy valve seats. The interchangeable valves are of "Silchrome" steel. Another distinctive feature is the use of "splash" lubrication, with an oil chamber in the big end. Even more unusual is the use of magneto ignition, selected probably to maintain commonality with the firm's two-stroke engines; the contact-breaker is, we are advised, adjustable quite easily without removing the flywheel.

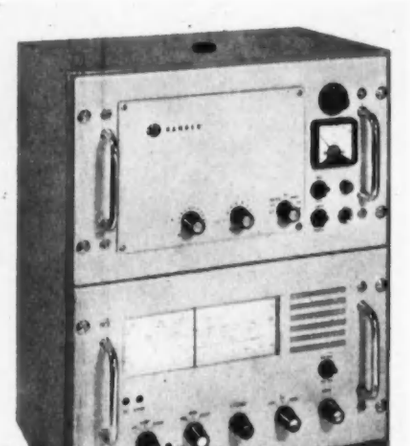
There are available recoil starters and a quart fuel tank. The carburetter may include an air-vane governor.

[Reply Card No. E5621]

Marine Radio-Telephone

COMMUNICATION and d/f facilities for small vessels having a 12V or 24V d.c. power supply are provided by the "Hamble" radio-telephone illustrated, of which we have received details from Pye Telecommunications, Ltd., Newmarket Road, Cambridge. The lower unit in the cabinet is the receiver, which uses transistors in all stages of a single-superheterodyne circuit with beat-frequency oscillator for c.w. reception. The wavebands covered are 562m–187m, 197·5m–79m and 79m–30m. For d/f working the receiver is used with a rotatable ferrite rod loop aerial similar to that of the Pye "Solent" equipment illustrated in our September 30, 1960, issue, but in the "Hamble" circuit the loop is untuned. As in the "Solent," the loop is integral with the d/f dial and is located in the centre of a compass rose which is set to a compass bearing, enabling radio bearings to be read directly relative to north. The d/f dial is rotated by its edge to find zero signal. When manipulated in this way, it is stated that hand-capacity effects are negligible in spite of the proximity of the ferrite rod, and that a reset accuracy of better than 1 deg. may be obtained.

The transmitter operates on eight crystal frequencies in the 187·5m–30m band with a normal output of 20W, reducible to under 10W by a low-power switch. A six-transistor modulator and a transistorised d.c./a.c. convertor are mounted on the transmitter chassis, the latter providing h.t. for the three transmitter r/f valves. The transmitter takes 8·5A on full power from a 12V supply and 7A from 24V. Manipulation



Transmitter and receiver of battery-operated radio-telephone for small craft

has been simplified to allow operation by users with little technical knowledge. The transmitter controls, from left to right, comprise aerial tuning, channel selection, and a multi-position switch enabling the principal operating conditions to be checked on a single meter. The high/low power switch and transmitter and receiver on/off switches are of uniform design, as are the various rotatable controls, so that any suggestion of complexity to those unfamiliar with the adjustment of transmitting equipment is avoided. A remote control unit is available for the equipment if required. Dimensions of the transmitter/receiver unit as illustrated are 16in wide by 11in deep by 17½in high.

[Reply Card No. E5622]

Rubber-Tyred Cranes

THE probable impact of the development of rubber-tyred cranes on industry, industrial buildings and plant layout, was outlined by Mr. E. M. Lewis* in a paper presented to the Institution of Structural Engineers on Thursday, March 23. After several years of development work W. S. Atkins and Partners, in collaboration with Strachan and Henshaw, Ltd., undertook the first application of rubber-tyred wheels to overhead travelling cranes two years ago, when two 2-ton cranes at the Aylesford Paper Mills of the Reed Paper Group were converted from steel wheels to rubber tyres.†

In his paper Mr. Lewis asserted that crane design, gantry girder and building design, and the planning of industrial schemes of all kinds would be widely affected by the change to rubber-tyred cranes. He said that with the elimination of the crane rail, steering would generally be by guide rollers. Where guide rollers were undesirable, for example for steering cranes along tracks which were expected to become very much out of alignment due to foundation movements, &c., then electrical steering using a simple sensing device independently controlling the motors in each end carriage would probably be used. With regard to the design of end carriages, in most cases the flexibility of the rubber tyres would prove sufficient to eliminate the need for balancing bogies.

There were several factors connected with the rubber-tyred crane which, taken together, would probably lead to lighter cranes:

(*a*) The elimination of shock would lead to lighter axle and end carriage assemblies.

(*b*) Smooth and reliable long travel would result in long travel motors of lower rating and therefore less weight.

(*c*) Long travel motors would generally be mounted on end carriages leading to a reduction in structural weight of the bridge.

(*d*) Elimination of balancing bogies in many cases.

(*e*) The practice of looking at the overall economy of the crane and the gantry together would undoubtedly lead to lighter cranes for long gantry structures.

The improved long travel motion, coupled with the increase in coefficient of friction between the wheels and the track by a factor of nearly 5 in the case of dry rubber on concrete, would lead generally to higher long travel speed. The present fast long travel crane moving at around 450ft per minute or approximately 5 m.p.h. might well travel at two or even three times this speed. Braking, acceleration and hoisting speeds would all be correspondingly increased to provide a harmonised production cycle.

Mr. Lewis thought that Goliath cranes, which have hitherto been used for production mainly on the cross-travel motion on account of the difficulties of fast and reliable long travel motion, would change over largely to rubber tyres. The flexibility of the tall structure would not upset the steering properties while long travelling, neither would it suffer from the relatively small steering forces if guide roller systems were used. Where electrical steering was used it could be foreseen that with the relatively small forces involved it would be an easy matter to make cranes which would go round corners where the planning requires. Further, it would be possible to make cranes which would climb gradients where the layout and site demanded.

In crane gantry buildings many changes in design could be foreseen with the advent of rubber-tyred cranes. The crane rail and its fastenings would be eliminated and would solve a particularly difficult problem in the case of concrete buildings with concrete gantries. Simpler and more economic designs of gantry girder supports, diaphragms, &c. would be feasible since a small gap between the ends would not matter and small differences of level could be tolerated. Cantilevered wheels would tend to reduce eccentricity of crane loads to the column and might lead towards greater use of single legged building columns—possibly extending the use of heavier rail sections. Foundations would no longer be designed with a view to limiting column head movement as at present.

Mr. Lewis concluded that the following were probable long term trends: Fast Goliath cranes suitable for running on displaced and undulating concrete ground tracks would virtually oust the conventional gantry in open yards carrying heavy loads on weak ground (such as many steel works slab yards) by virtue of their reliability in operation. They would also be used in many installations where, by the elimination of a long gantry structure, they might offer substantial capital savings on the scheme as a whole. The potential availability of rubber-tyred Goliath cranes which can steer, travel from one building into another and climb gradients would give those concerned with the planning and plant layout of industrial schemes two additional degrees of freedom and would inevitably result in some important changes which cannot now be clearly foreseen. The elimination of rail tracks and the closer grouping of buildings, however, appeared likely.

* Director of Research and Development, W. S. Atkins and Partners.

† THE ENGINEER, May 6, 1960, page 771

Two-wheeled dumper of 5 to 7 cubic yards capacity. It is drawn by a standard tractor from which it can be rapidly uncoupled after extending the jack shown under the goose-neck to give forward support

Detachable Dumper

THE accompanying illustration shows a dumper known as the "Morewear Goose," which is made by R. Smith (Horley), Ltd. and distributed by Mackay Industrial Equipment, Ltd. The dumper is a two-wheeled vehicle of all-welded construction, with a goose-neck at its forward end, where it couples onto the tractor. The tractor can be any one of a number of standard machines—in this case a Fordson "Super Major" of 50 h.p.—which has a towing hitch bridge bolted to it immediately below the driver's seat. A 3in diameter hardened-steel ball forms the operative part of this assembly, and a forged cup assembly (the cup is also 3in in diameter, with a precisely machined surface with grease channels and greasing nipples) is bolted on to the goose-neck of the dumper. A simple locking device ensures that the cup will not lift off the ball. This ball joint coupling allows over 100 deg. of articulation on each side, about 40 deg. of lateral movement above or below the horizontal of either vehicle, and practically unlimited articulation in the vertical plane (e.g. when travelling over a hump-back), it is claimed. A 60-ton shear test has been carried out successfully on the ball coupling and its adjacent assemblies. The coupling is situated 3½in ahead of the rear wheels of the tractor, but nevertheless a 700 lb weight is bolted to the front of the tractor to give stability in traction.

A hydraulic jack is fitted under the goose-neck, and can be extended to support the front of the dumper and to lift the cup clear of the ball. Thus the two machines can be uncoupled in ninety seconds. Two loading stands are also bolted to the main frame to give additional front support. If the tractor is fitted with loading equipment, it can, therefore, be used both to load and pull the dumper. Flexibility of operation with standard tractors has thus been a principal objective in design. For this reason too, "unit" construction is embodied in the dumper, parts of which can be simply replaced. The dumper has a capacity of 5 to 7 cubic yards (i.e. 8 tons to 10 tons). The illustration also shows a clam gate tail board fitted, and the linkage which operates it. The dumper can be tipped up to an angle of 60 deg. by a simple ram arrangement operated from the tractor.

[Reply Card No. E5631]

Trace Reader

A METHOD of reading recorder charts developed at the Thornton, Cheshire, Research Centre of "Shell" Research, Ltd., is proving of considerable value in reducing time and fatigue in the analysis of data displayed as a changing variable on a moving paper trace. In the Thornton trace reader the record trace rests on a table movable by means of two lead screws along x and y axes (e.g. time and pressure) in the horizontal object plane of a projection lens. A small region of the chart around the lens axis is illuminated and back-projected at fixed magnification (×4) on a viewing screen as illustrated. This screen is ruled with two fixed intersecting diameters parallel to the table motions. By moving the table so that the image of any point on the trace line coincides with the intersection of the viewer lines, each co-ordinate

Recorder trace magnifier with digital voltmeter display of co-ordinate values

of that point is converted to a voltage between the sliders of a pair of multiturn potentiometers connected in parallel.

One potentiometer is geared to the respective lead screw and the other manually adjustable. The latter permits any point to be made the origin of co-ordinates by reducing the corresponding voltage to zero. Without disturbing the origin, the co-ordinate scales may be fitted independently to any linear chart calibration (usually to numerical correspondence) by manually adjusting the voltage across the appropriate pair of potentiometers. The x or y co-ordinate voltage, selected by a switch, is displayed on a 0 to 999 digital voltmeter with an accuracy corresponding to one or two thousandths of an inch on the record trace.

The x and y table motions are 7·5in and 4·75in respectively and the projected area of the trace is 2in in diameter. Whilst this instrument has been designed for inkless recordings, it will handle other types of trace up to 120mm in width, including transparencies if a white backing is placed beneath. The instrument can be used on any bench or table capable of supporting 70 lb with an area of 4 square feet. It has been of material value in analysing the pressure surges that take place in hydrant fuelling systems for aircraft.

[Reply Card No. E5632]

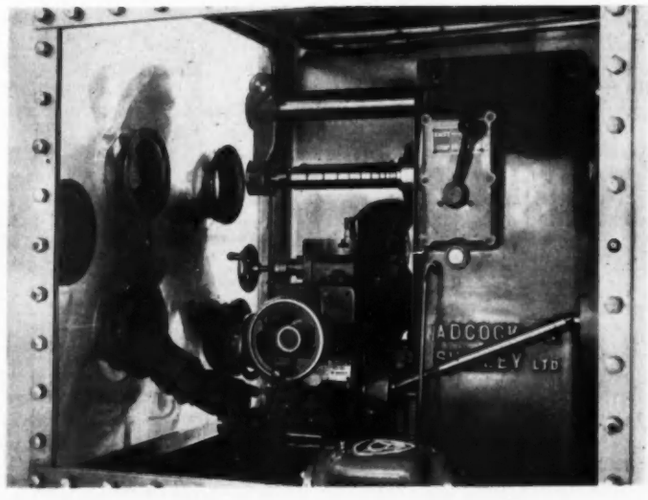
Glove Box Enclosed Milling Machine

WE reproduce a photograph of a milling machine specially built by Adcock and Shipley, Ltd., Ash Street, Leicester, for use in glove box machining in a British atomic power station. With this machine, specially modified to enable it to be used with safety on radioactive materials, the operator is completely insulated from the machine by the box and the gloves. At no time does he come into contact with the machine, swarf or job.

To overcome the difficulty of speed changing by the normal method of moving belts over stepped pulleys, the standard transmission has been replaced by a Kopp "Variator." This "Variator," and the 3 h.p. motor which drives it, are installed outside the glove box and the drive to the machine taken through a long shaft with a running seal. The shaft was super-finished to avoid wear on the seal and is extended into the base. In the base the shaft carries a six-groove pulley driving through six belts to a pulley mounted on the spindle. The "Variator" gives output speeds from 480 to 4320 r.p.m. from a constant input of 1440 r.p.m. The vee belts give a 2 to 1 reduction so that, in conjunction with a back gear, a speed range of 30 to 2160 r.p.m. is provided.

In order to facilitate operation through the gloves, hand wheels instead of ball handles have been fitted and those operating the knee and cross slide have been reversed to make the operation more convenient. Pipes have been taken from the oil drain holes in the column and cross slide gear boxes so that the draining of the oil from the gear boxes and refilling can be effected from outside the cabinet. The vertical milling attachment shown in the illustration remains permanently inside the cabinet and is taken off and put on the table with the aid of a crane, mounted overhead in the box.

[Reply Card No. E5633]



Milling machine, for use in preparing radioactive materials, enclosed in a glove box

INDUSTRIAL NEWS

Wages and Hours of Work

Changes in rates of wages and hours of work reported to the Ministry of Labour as having come into operation in the United Kingdom during February are estimated to have resulted in about 1,989,000 workpeople receiving an aggregate increase of approximately £436,000 in their full-time weekly rates of wages, whilst 70,000 workpeople had their normal weekly hours reduced by an average of two hours.

Adult workers in the building and civil engineering industries received increases of ½d. an hour during February. In the coal mining industry the majority of day-wage workers received increases of 1s. 5d. a shift, and there were increases of 1s. 10d. or 2s. 6d. a shift for certain engineering and craftsmen grades. Minimum weekly rates agreed by the National Joint Industrial Council for the motor vehicle retail and repairing trade were increased by amounts ranging from 6s. 8d. to 8s. 10d. a week for men and by 6s. 5d. or 6s. 7d. for women. Increases of 8s. 6d. a week for craftsmen, 8s. for semi-skilled workers, and 7s. 6d. for unskilled workers employed in Admiralty dockyards were authorised with retrospective effect to January 9. Workers paid on an engineering basis in Government industrial establishments received increases ranging from 7s. 6d. to 8s. 6d. for men and of 7s. for women. Heating, ventilating and domestic engineering workers received increases of 3½d. an hour for craftsmen, of 3d. for adult mates, and of proportional amounts for apprentices.

The Ministry of Labour says, that of the total increase of £436,000, about £161,000 resulted from arrangements made by Joint Industrial Councils or other joint standing bodies established by voluntary agreement ; £149,000 from direct negotiations between employers and trade unions ; £123,000 from the operation of sliding scales based on the official index of retail prices ; and the remainder from orders made under the Wages Councils' Acts.

Coal

The National Coal Board is to make a special effort to increase productivity in coal mines in 1961, its aim being to reduce working costs by mechanising the "coal-getting" process at a higher rate than ever before and to improve the production of coal by more efficient methods. The power-loading of coal had made little progress in this country, the Board states, until machines suitable for British mining conditions started to be developed a little more than ten years ago. In 1950 only 3·8 per cent of the total tonnage was won entirely by machine, but progress since then has been rapid and in 1960 the proportion mined in this way was 38·2 per cent, which amounted to 83,000,000 tons. Last year the percentage of power-loaded coal rose by six points from 32 to 38 per cent, and this year the Board intends to raise the percentage by ten points to 48 per cent of saleable output. Up to 400 new machines are to be installed with the aim of increasing the power-loaded output by 22,000,000 tons.

The three machines leading the drive will be the Anderton shearer-loader, the trepanner, and the coal plough, which between them, the Board says, accounted for 63 per cent of the power-loaded coal total in 1960. The Anderton shearer has proved itself to be a very efficient and reliable machine which can be used in the widest range of mining conditions, the Board adds, but because of the need to increase the production of large coal, the emphasis will be on installing more ploughs and trepanners.

Balance of Payments

The White Paper, Cmnd. 1329, published last week, entitled "United Kingdom Balance of Payments, 1958 to 1960," shows that the deficit on visible trade increased from £69,000,000 in 1959 to £366 million in 1960. Imports rose by £499 million and were 14 per cent higher than in 1959, while exports and re-exports were £202 million higher, a rise of 6 per cent.

Considerable changes have been made in the basis of compilation of the balance of payments statistics since the last half-yearly White Paper was issued, and it is pointed out that the estimates for 1958 to 1960 in this Paper are not comparable with those published for earlier years.

During 1960 the balance of monetary movements was adverse to the extent of £168 million. In 1959 the adverse movement was £380 million, but allowing for special capital transactions, the comparable figure was £119 million. The gold and convertible currency reserves rose by £177 million during 1960.

The White Paper points out that the surplus on invisible account fell from £120 million in 1959 to £22,000,000 in 1960, thus continuing the deterioration already evident between 1958 and 1959. Bringing together visible and invisible transactions, the identified balance on current account moved from a surplus of £51,000,000 in 1959 to a deficit of £344 million in 1960, a deterioration of £395 million. Private direct investment abroad by the United Kingdom increased slightly to £185 million. Direct investment in the United Kingdom increased rather more to £148 million.

Employment and Unemployment

The main features of the manpower situation in Great Britain during 1960 were a growth of over 250,000 in the working population, an increase of nearly 400,000 in the number in civil employment, a decrease of about 90,000 in the number wholly unemployed and a reduction of over 30,000 in the Forces. Women and girls, the Ministry of Labour says, accounted for two-thirds of the overall increase in the working population. The number of people in civil employment at the end of the year, the Ministry says, was estimated to be over 23,700,000, comprising nearly 15,600,000 males and over 8,100,000 females.

There were increases in most fields of employment, the Ministry says, other than mining, agriculture and fishing and shipbuilding. About two-thirds of the overall increase was made up of some 229,000 in the manufacturing industries and about 43,000 in the construction industries. The contraction of employment in mining, 54,000, occurred mainly in the first half of the year. In shipbuilding and marine engineering the number employed dropped by 14,000. There were increases of 94,000 in the engineering and electrical goods group, 34,000 in the metal manufacturing industry, 23,000 in miscellaneous metal goods manufacturing, and 16,000 in motor vehicle manufacturing, the Ministry says, despite a fall in the latter part of the year.

The number of unfilled vacancies in 1960, rose to a seasonal peak of about 380,000 in July, the Ministry reports, the number subsequently dropping by rather more than the normal seasonal decrease. The December figure of 294,000 was over 40,000 higher than the December, 1959, figure. The demand for labour was higher at the end of 1960 in agriculture and all the other main industrial groups than at the end of 1959.

European Free Trade Association

An agreement of association between the member states of the European Free Trade Association and Finland was signed in Helsinki last week. Under the agreement, the Board of Trade states, Finland and the members of EFTA assume broadly the same commercial rights and obligations towards one another as the members of EFTA have already assumed between themselves. The exception as far as tariffs are concerned is that Finland may reduce its import duties on certain goods in accordance with a retarded time-table, but must catch up again with the standard time-table by January 1, 1967. The main goods in question, the Board of Trade says, are textiles, tyres, and a range of iron and steel manufactures. Finland may also retain indefinitely its quantitative restrictions on imports of solid and liquid fuels, tars, bitumen &c., and certain kinds of fertilisers.

The European Free Trade Association retains its own separate council but a joint council is to be established to administer the new area of eight countries. The first tariff reductions are to become operative on July 1, 1961.

Scientists and Technologists

The first Diplomas in Technology to be awarded to students at the Brighton Technical College were presented last week by Mr. Antony Part, deputy secretary, Ministry of Education. Commenting on the annual output of at least 20,000 scientists and technologists which the Government had adopted as an objective for 1970, Mr. Part said that it now seemed certain that this figure would be reached at least five years ahead of time. The technical colleges in England and Wales will produce over 9000 scientists and technologists in the mid-1960s, Mr. Part added, compared with about 5000 in 1956. Moreover, most of those who qualified from the colleges five years ago had taken part-time courses, whereas in the mid-1960s a much higher proportion will have taken full-time or sandwich courses. The introduction of sandwich courses leading to the Dip. Tech. had given a great fillip to the colleges, Mr. Part said, and instead of working in comparative isolation, they now had close links with industrial and research establishments in many parts of the country, while the responsibility for the planning of syllabuses and for the examining of students has given a new sense of freedom and purpose to all concerned.

PERSONAL AND BUSINESS

Appointments

MR. R. L. GLAISHER has joined Adrema (Holdings), Ltd., as overseas operations manager in charge of the export and merchanting activities.

MR. KENNETH ARTHUR OLIVER has been appointed chief metallurgist of the Brightside Foundry and Engineering Company, Ltd.

MR. N. E. N. PLAHN, managing director of Fuller Electric, Ltd., has been appointed to the board of Hawker Siddeley Industries, Ltd.

BELLING AND LEE, Ltd., has announced the appointment of Dr. A. C. Robb, A.M.I.E.E., as technical manager.

MR. W. C. M. MATTERSON, founder and managing director of Matterson, Ltd., retired on March 31. He has been succeeded by his son, Mr. R. Kelvin Matterson.

THE INTERNATIONAL NICKEL COMPANY (MOND), Ltd., states that Mr. H. W. G. Hignett and Mr. Jean M. Dhavernas have been appointed directors. Mr. Hignett remains managing director of Henry Wiggin and Co., Ltd.

THE INSTITUTION OF WORKS MANAGERS has elected as vice-presidents of the Institution Mr. E. J. Hunter, chairman of Swan, Hunter and Wigham Richardson, Ltd., Mr. J. R. Edwards, managing director of Pressed Steel Company, and the Hon. Geoffrey Rootes, deputy chairman and managing director of Humber, Ltd.

AVELING-BARFORD, Ltd., states that, for reasons of health, Mr. W. M. T. Branson, home sales manager since 1946, is to go into semi-retirement. In consequence, a new post has been created—sales manager, earthmoving, home—to which Mr. J. R. Pulfrey has been appointed. Mr. H. Wynne has been appointed home sales office manager.

A.E.I. LAMP AND LIGHTING COMPANY, LTD., announces that Mr. F. Widnall, M.I.E.E., manager and engineer of the Hereford Lighting Equipment Works, has been appointed manager of the company's lighting engineering department with his office and laboratories at Melton Road, Leicester. He has been succeeded as manager of Hereford Works by Mr. T. W. Grieve.

SIR ELLIS HUNTER has retired from all executive appointments in the Dorman Long Group, including the Joint managing directorship of Dorman Long (Steel), Ltd. He continues as chairman of Dorman, Long and Co., Ltd., and its principal subsidiary companies. Mr. E. T. Judge has been appointed Deputy chairman of Dorman Long and Co., Ltd., and managing director of Dorman Long (Steel), Ltd., of which he was previously joint managing director.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., announces that Mr. Michael J. S. Clapham, chairman of I.C.I. Metals Division since January 1, 1960, has been appointed a director. He is to be an overseas director *vice* Dr. J. S. Gourlay, who is to be Group "A" director, responsible for alkali and general chemicals divisions. Imperial Chemical Industries, Ltd., has also announced that Mr. Harold Smith, chairman of I.C.I. general chemicals division for the past two years, has been appointed a director. He will take over as technical director from Dr. Richard Beeching on June 1 when Dr. Beeching becomes chairman of the British Transport Commission.

THE BRITISH BROADCASTING CORPORATION states that Mr. C. H. Colborn, M.I.E.E., who is retiring after thirty-seven years' service, will be succeeded as head of the television studio section, planning and installation department, by Mr. D. R. Morse, A.M.I.E.E. The Corporation also announces that Mr. R. J. Keir, A.M.I.E.E., resident engineer of the B.B.C. Far Eastern Station, Singapore, will complete his term of duty in April this year and will be succeeded by Mr. D. N. H. Lambert, A.M.I.E.E. Mr. K. G. Nicholas has been appointed engineer-in-charge of the B.B.C. television studio at Southampton, a newly-created post following on the extension of the technical facilities at this studio. Mr. E. S. Ahl, engineer-in-charge of the B.B.C. Penmon and Llanddona sound transmitting stations, now becomes engineer-in-charge also of the B.B.C. Bangor studios in succession to Mr. S. Hett, who is retiring after thirty-seven years' service.

Business Announcements

KETAY, Ltd., Eddes House, Eastern Avenue West, Romford, Essex, states that it can now supply the new miniature integrating gyro, type RI-203, recently introduced by the Norden Division of United Aircraft Corporation.

OPPERMAN GEARS, Ltd., has formed a new company, L.S.A. (Exports), Ltd., a subsidiary of Opperman Gears (Holdings), Ltd., which will operate from offices in Hambridge Road, Newbury. Mr. Peter Bollen, M.I.Ex., has been appointed managing director of the new company.

SIMMS MOTOR UNITS, Ltd., Finchley, London, N.2, announces that in the early part of last year it was awarded a contract by the Ford Motor Company of Detroit, U.S.A., to supply all the fuel injection equipment for the new Ford six-cylinder diesel "6000" tractor. Deliveries to Detroit of these Simms units began towards the end of 1960.

HAWKER SIDDELEY INDUSTRIES, Ltd., announces that the electronics sections of Armstrong Whitworth Aircraft, Ltd., and Brush Electrical Engineering Company, Ltd., have been linked to form a partnership, known as Armstrong Whitworth/Brush, to manufacture and market advanced electronic and electrical control and intelligence systems.

RUBERY, OWEN AND CO., Ltd., P.O. Box 10, Darlaston, Staffs., announced on January 20 that it would discontinue the manufacture of the Rubery Owen press brake guard upon completion of outstanding orders. The company has now announced that as from April 30, the manufacture and service of these guards will be undertaken by Boucher and Co., Ltd., Pike Mills, New Road, Kidderminster, and they will be marketed under that company's name.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., 21, Bloomsbury Street, London, W.C.1, has formed a new company, Telcon Plastics, Ltd., Green Street Green, Orpington, Kent, which will take over the entire range of activities of the plastics division of the Telegraph Construction and Maintenance Company, Ltd. The board of directors of Telcon Plastics, Ltd., will be constituted as follows: Mr. W. C. Smith, chairman; Mr. J. L. Fergus, general manager; Mr. D. Norman-Thomas and Mr. H. F. Wilson, Comp. I.E.E. The company secretary will be Mr. L. G. P. Sliney.

CANADIAN AVIATION ELECTRONICS, Ltd., Montreal, FERRANTI-PACKARD ELECTRIC, Ltd., Toronto, and THE DE HAVILLAND AIRCRAFT OF CANADA, Ltd., Toronto, have announced the formation of a jointly owned subsidiary to be named DCF Systems, Ltd., to undertake management, design, development and manufacture relating to commercial and military equipment programmes in those fields where the companies' capabilities and facilities are complementary. The company directors are Messrs. J. F. Tooley, John Fogarty, D. B. Annan, L. D. Clarke and W. H. Jackson, who has also been appointed general manager. The head office of the company is at Downsview, Ontario.

CIBA, Ltd., Basle, has formed a company in the United Kingdom with an authorised share capital of £3,000,000 under the name of CIBA United Kingdom, Ltd. The registered office of the company is 96, Piccadilly, London, W.1. This company will act as the holding company for the CIBA interests in the United Kingdom by acquiring from CIBA, Ltd., Basle, the issued share capital of its three wholly owned United Kingdom subsidiary companies, CIBA Laboratories, Ltd., CIBA Clayton, Ltd., and CIBA (A.R.L.), Ltd., together with the controlling interest held by CIBA, Ltd., Basle, in the Clayton Aniline Company, Ltd. Dr. Dr. h. c. R. Kappeli (Swiss) has been appointed the chairman of CIBA United Kingdom, Ltd., and Sir Arthur Vere Harvey the managing director. Dr. Dr. h. c. A. Wilhelm (Swiss), Dr. A. Brunner (Swiss) and Sir Joseph Napier, Bt., have agreed to join the board of directors.

Contracts

TARMAC CIVIL ENGINEERING, Ltd., has received a contract worth approximately £350,000 from Staffordshire County Council for the development of the A.38 Lichfield to Burton-on-Trent road between Alrewas and Wychnor Farm. Approximately 1¼ miles of dual carriageway will be added to the present road to link with the existing dual carriageway. Staffordshire County Council (county surveyor, Mr. F. Jepson, O.B.E., M.I.C.E., A.M.I.Mun.E.) is acting as agent authority to the Ministry of Transport.

MILLSPAUGH-WIMPEY, Ltd., Hammersmith Grove, London, has been awarded a contract worth more than £3,000,000 for the establishment of a complete paper mill in Yugoslavia. More than 90 per cent of the equipment for the project will be manufactured in Britain, much of it in Sheffield.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, Ltd., has received contracts valued at approximately £2,000,000. They include orders for rolling mill plant to be built under the recent agreement between Wellman and Schloemann, A.G., for an LC/AC. oxygen steelmaking unit for Stewarts and Lloyds, Ltd., Corby, under the Wellman-Voest agreement and for mill cranes for Shelton Iron and Steel, Ltd.

CONCRETE DEVELOPMENT, Ltd., Iver, Bucks, has been awarded a contract valued at £188,000 under which nearly 25,000 precast concrete floor and roof units are to be designed, supplied and erected for the new Fisher and Ludlow factory at Llanelly. First delivery of the units will be made this month. The architects for the project are H. W. Weedon, F.R.I.B.A., and Partners, 45-47, Calthorpe Road, Edgbaston, Birmingham.

HOLLAND & HANNEN AND CUBITTS (SCOTLAND), Ltd., has been awarded a £1,750,000 contract for building work at Royal Air Force, Fylingdales, Yorkshire, by the Air Ministry. Work is to start immediately and must be completed by the end of June, 1962. The contract is for work in three radar buildings and the construction of domestic and administrative buildings. The consulting engineers are Sir Alexander Gibb and Partners.

HEAD WRIGHTSON (AUSTRALIA) PTY, Ltd., Sydney, a subsidiary of Head Wrightson and Co., Ltd., has received orders valued at approximately £3,500,000 from the Broken Hill Proprietary Company, Ltd., and from Australian Iron and Steel, Ltd. The orders include the design, manufacture and erection of a scree ore treatment plant, a basic oxygen steelmaking plant and a tinplate cut-up line.

The tinplate cut-up line will be built to the designs of the Head Wrightson Machine Company, Ltd., partly in Middlesbrough but mainly in Australia. It is a repeat order, a similar line having been commissioned at Port Kembla a few months ago. The line is designed to operate at speeds up to 800ft per minute, and will cut steel strip of up to 40in wide, in coils weighing up to 45,000 lb, into sheets for hot-dip tinning.

The basic oxygen steel plant will have an output of about 500,000 tons of steel a year. It will be engineered by Head Wrightson Iron and Steel Works Engineering, Ltd., and installed at Whyalla, South Australia.

Head Wrightson Minerals Engineering, Ltd., will be responsible for the ore treatment plant, which will treat 1,200,000 tons of scree deposits a year and produce 800,000 tons of concentrate averaging about 60 per cent iron content.

Miscellanea

ADHESIVE FOR POLYURETHANE.—A new adhesive made to a rubber/resin formula, developed by the Industrial Adhesives Division of Evode, Ltd., Stafford, is stated to provide a strong resilient bond when joining polyurethane or polyether foam to materials such as fabric, wood, metal, &c., without affecting the microcellular structure of the foam. The adhesive, which provides a strong bond for microcellular foam to itself without causing any hardening effect at the joint, is water and oil-proof, and resistant to high temperatures.

Death

WE record with regret the death of Mr. F. W. Endicott, Scottish engineer, British Broadcasting Corporation. He died in Glasgow on March 21 at the age of sixty. Mr. Endicott, who was born at East Budleigh, Devon, had served for thirty-one years with the engineering division of the B.B.C. which he joined in 1929 as an assistant in the technical correspondence section in London. He moved to Scotland in 1937 when he became assistant engineer-in-charge at Glasgow. He was appointed engineer-in-charge, Glasgow, in 1942 and regional studio engineer in 1950. In this latter capacity Mr. Endicott was redesignated Scottish engineer in 1955 and was responsible for the engineering services of the B.B.C.'s sound and television studios and outside broadcast units in Scotland.

CONTINENTAL AFFAIRS

by Our Continental Editor

Inland Ship Research Station

ON account of the large and increasing volume of navigation on inland waterways in Germany, much attention has been and is being paid to research into the design of suitable vessels. This work was previously carried out by the Berlin and Hamburg tanks which, however, are mainly intended for seagoing ships. There was thus a need for a research station specially laid out and equipped to undertake investigations in connection with inland craft; the result was the setting-up of the Duisburg Experimental Station (Versuchsanstalt für Binnenschiffbau e.V.), a non-profit-making organisation attached to the Rhenish-Westphalian Technical University in Aachen, and co-operating closely with Duisburg Engineering College.

The station was built in two stages of which the first stage, which was completed in June, 1954, included a large and a small towing tank, a manoeuvring basin, and some workshops and administration offices. In the second stage, concluded as far as the structure was concerned in March, 1958, both tanks were lengthened, more pumping capacity was installed, and workshop and office space was extended.

Fig. 1 shows the layout of the research station, while Figs. 2 and 3 show the view down the main hall from opposite ends.

The large towing tank is 9·8m wide and has an overall length of 148·72m; the depth of water can be varied between zero and 1·1m. Parallel to it but separated by a gangway is the small tank which is 3m wide throughout, and is divided into a 60·5m long shallow section in which the depth can be varied as in the large tank, and a deep section 73·04m in length where the depth is 2·75m. At the end of the narrow tank is the 1·1m deep manoeuvring basin which measures 25m by 25m. The water entering from the narrow tank is reversed by guide vanes into the large tank. Our second illustration shows these guide vanes which separate the flow into six channels. These channels contain adjustable gates as well as stilling screens. Together with an additional wire screen and a 60cm thick honeycomb, both extending over the full width, they ensure a very even velocity distribution. A wave attenuator at the head of the tank can be lifted out of the water during flow experiments.

The pumping installation consists of two propeller pumps, each of 7000 cubic metres per hour capacity. They can generate a speed of flow of 1·5m per second in the large towing basin, and up to 2·4m per second in the small basin.

The towing carriage runs on a track having a gauge of 11·4m which straddles both the larger basin and the gangway. Electric current is obtained from overhead conductor rails situated above the gangway. The carriage is a trussed structure having a working platform with opening over the centre of the main basin. A cantilevered subsidiary platform which can be slewed in and out of position serves the small tank. A 33kW d.c. motor enables the carriage to reach its maximum speed of 5·5m per second over a distance of 30m within twelve seconds. Because the towing resistance increases much more steeply with speed in shallow water than it does in deep water, the effect of speed fluctuations in the Duisburg tank is correspondingly greater than in the case of tanks representing the open sea. For this reason it must be possible to maintain the set speed within the very close limits of ±3 to 4 parts per thousand. Instead of a Ward-Leonard control, the drive incorporates the improved version of an electronic control for rolling mills. The device, built by AEG, compares the speed set by means of a frequency

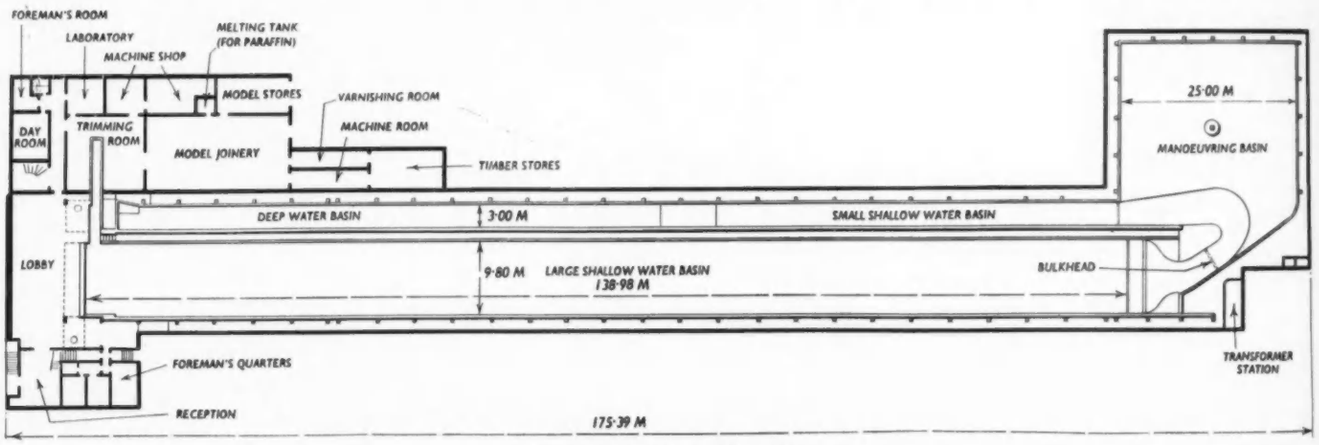


Fig. 1—Layout of research station

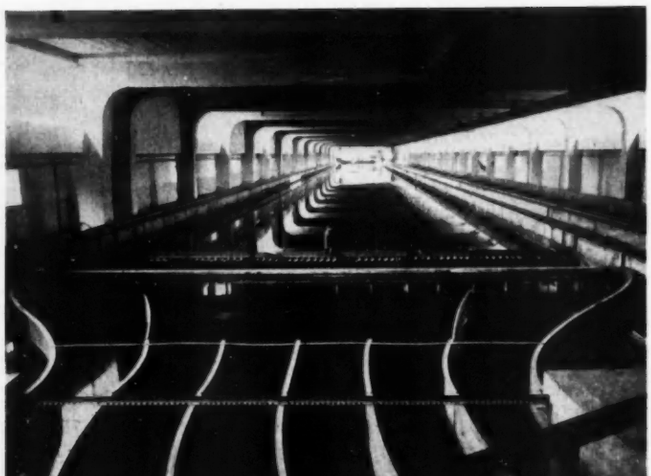


Fig. 2—View of towing tanks from the inlet end of the large tank

Fig. 3—Small and large towing tanks and towing carriage

standard with the actual speed measured by towing a magnetic tachometer wheel. The impulses from the latter are repeatedly counted over a set period by an electronic counter, thus providing automatically readings of the carriage speed which can be maintained at any value between 0·02m and 5·5m per second.

The dimensions of the model tanks, the design of the carriage, and the pumping plant, were chosen so as to simulate experimentally conditions arising on the German as well as most foreign inland waterways. For measurements involving the passage of ships in opposite directions, a subsidiary towing carriage is to be installed on a track with rails on either side of the gangway. For work in the supercritical range, small high-speed models may be towed at speeds of up to 9m per second by means of a winch.

The manoeuvring tank is equipped with a rotating towing arm attached to a central column. More elaborate tests and manoeuvres can be carried out by using the Decca eight-channel v.h.f. equipment recently installed. This permits battery-powered models to be remote-controlled. Roll and yaw angles can be obtained photographically by means of cameras mounted on the models which record markings at the side of the tank. Other readings have to be recorded or transmitted through wires, but radio-telemetry is to be installed later. The manoeuvring tank is used not only for research, but also for demonstrations and the training of crews.

The auxiliary installations include workshops for the construction of models and propellers. A channel connects the tank with the trimming room which is situated adjacent to the model joinery and varnishing shops. In general models are built from wood. A number of rough-sawn boards are glued together to establish the approximate shape, which is then machined on a double-spindle copying router so as to establish the correct lines. The model is hand-planed down to the router lines to a smooth shape, sanded and given several coats of varnish. The shape is checked with templates, and where necessary corrected by applying a filler. A large number of man-hours are spent on this final and most laborious stage of the work. In cases where the same shape of hull is to be repeated, models are made from glass-fibre reinforced plastic with the help of a pattern.

Model propellers varying in diameter from 80mm to 250mm are produced by predrilling from opposite sides and hand-finishing the blades to the shape defined by the drill spots. About 100 to 200 hours of work are required to complete each propeller.

Semiconductors in Motor Vehicles

Since the invention of the transistor by the Bell Laboratory in 1948, the development of semiconductor diodes and transistors has advanced to the point where diodes can handle currents of over 100A and transistors over 10A. Such performance renders these components suitable for use in electric equipment for motor vehicles. Thus, the diode finds application in place of the cut-out of d.c. generators, and can replace the commutator in commutator-less d.c. machines. It has the advantage of contactless and therefore noiseless operation, longer working life, insensitiveness to vibrations, and smaller overall dimensions. Compared with selenium rectifiers, the losses are smaller, the weight and dimensions less, and the maximum permissible working temperature higher.

In order to maintain a constant dynamo voltage and to limit the current to a permissible value, use is made of a combination of Tirill voltage controller, electromagnetic current controller (vibrator), and electromagnetic cut-out. In some controllers put on the market by Robert Bosch G.m.b.H., Stuttgart, the mechanical current controller is replaced by a semiconductor called a "Variode" and the current cut-out by a power diode. The latter is placed inside the dynamo housing where it is cooled by the dynamo fan.

The small "Variode," which is readily mounted on the same base as the voltage controller, is built like a diode, and exhibits in the "conducting" direction a strongly curving characteristic. This enables it to operate in dependence upon the dynamo current. By suitably choosing the circuit parameters one can get the "Variode" to become conducting only when the maximum dynamo current has been reached; this lowers the control voltage. A shift of the "Variode's" characteristic due to changes in temperature makes it possible to improve the charging of batteries in cold weather. The "Variode" is claimed to measure about 100 times less than the element which it replaces, and to be cheaper to make.

The current diode is a power diode of normal design and in the normal manner prevents the battery from discharging through the dynamo during standstill. Because of the absence of moving parts the diode functions without noise, and it is no longer necessary to drive the dynamo in such a way as to avoid cutting in and out at the idling speed. This enables the dynamo to be driven at its maximum speed, with the result that in many cases some power is generated during idling,.

The transistor can replace mechanical interrupters, and moreover can be used advantageously to control voltages and operate battery ignition. Its efficiency is high at the low voltages used in cars.

In the partially transistorised battery ignition, for instance, the circuit breaker is retained in its traditional form but carries only the transistor base current, while the full current in the primary of the ignition coil, amounting to about thirty times the base current, is supplied by the transistor acting as an amplifier. This conserves the breaker contacts, and at the same time allows the spark frequency to be raised above its present limit of some 18,000 per minute, to about 30,000 per minute. In the version made by Robert Bosch G.m.b.H., the transistor is incorporated with the ignition coil in the same casing. An even higher spark frequency (which would be of interest for multi-cylinder, high-speed engines) could be achieved by a fully transistorised ignition system. The solution suggested by Bosch has an a.c. generator coupled to the camshaft. The generator has the same number of pole pairs as the engine has cylinders. This generator transmits impulses by way of a transistor flip-flop to the power transistor which controls the ignition current. Timing can be carried out either mechanically, by varying the phase of the generator drive, or electrically by varying the phase of the control impulses.

Stockholm Underground Car Park and Shelter

Ten years ago, the Swedish civil defence authorities decided to build in Stockholm four large underground garages, suitable as bomb shelters in wartime. The last of these has recently been opened. It is known as "P-Klara" and is situated in the heart of downtown Stockholm below the Klara Church in the vicinity of the Central Station. Parking in commercial use 300 cars, it can give shelter to 15,000 persons in an emergency and provide sleeping accommodation for 4000.

The garage-shelter has cost Kr.22,000,000. Altogether the four dual-purpose installations have called for investments of about Kr.60,000,000 (£4,138,000). They have a total parking capacity of 2200 cars and provide bomb shelter for 50,000 people.

Work on the "P-Klara" garage commenced in 1954, with Svenska Entreprenad AB (Sentab) and AB Armerad Beton as contractors. In September, 1955, the blasting of the 100m long sloping driveway began and in three years the tunnel-driving and rock reinforcement operations were completed. About 65,000 cubic metres of rock have had to be removed and 10,000 roof bolts with an average length of 0·3m were put into position. The construction work required 12,000 cubic metres of concrete and 900 tons of reinforcing steel. Built as an ellipse, the garage has two parking decks, each of which is divided into two sections for seventy-five cars. A special colour—red, blue, green or yellow—has been chosen for each section in order to make it easier for the driver-customers to find their way underground. The parking places are not numbered, but a built-in device in the two-way driveway registers automatically every car that leaves the garage.

While all cars arrive and leave via the main entrance driveway, two lifts, one leading to the main entrance and the other to an exit in a side street, carry the customers to and from street level.

Operated by the co-operative motoring and servicing organisation IC, which rents the space from the Stockholm Civil Defence authorities, the garage is open all round the clock. Services include a petrol station at street level and a large underground greasing station, as well as several car-washing posts.

Much attention has been paid to designing the establishment for use as a wartime shelter. Between the sloping driveway and the shelter-garage itself are four steel and concrete gates, each weighing 35 tons, which can be closed in a few seconds. The gates are provided with detonation shock absorbers, while special air locks—which can be mounted behind the gates in less than half an hour—effectively shut out poisonous gas or radioactive dust.

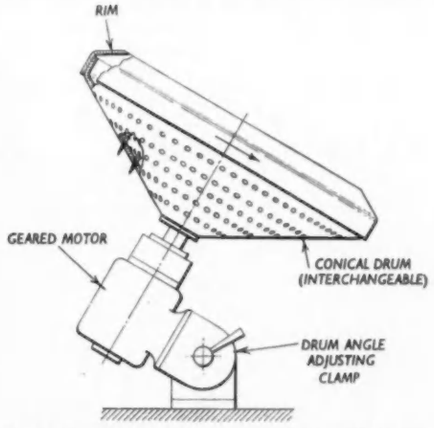
The ventilation equipment, supplied by AB Bahco, includes ninety-four air coolers to offset the inconvenience of the heat that inevitably would be generated by large crowds of people hermetically locked up in the shelter for some time. Water pumps with a capacity of 5000 litres per minute will pump cool water from a large ice basin at 25m to 30m below ground level. The basin holds 145 tons of ice, the production of which can start at a minute's notice.

In case the electric supply from the outside should be cut off, a standby power plant installed in the four-storey machinery house will go into immediate operation, producing 500kVA.

As a preparatory measure for an emergency a broad passage with a staircase has been opened up between the garage and the adjacent T-Centralen subway station. A thin wall at present separates the staircase from the station, but this wall can easily be torn down in order to make possible a quick descent to the shelter.

Automatic Jig for Small Turned Parts

Screws and other turned parts which are to be electroplated or lacquered are usually inserted in holes in sheet metal holders. To do this by hand is a laborious procedure. A recent issue of *Die Technik* describes an automatic device which achieves the same purpose. As shown in the accompanying illustration the device consists



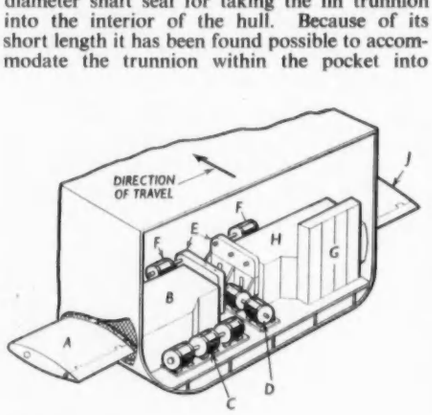
Device for inserting screws and other small turned parts into holder prior to electroplating, &c

of an inclined conical drum rotating at about 15 r.p.m. and provided with 800 to 1500 holes. For screws up to 8mm diameter the holes are drilled 10-6 per cent oversize. The rim of the hole is recessed on the leading part of the periphery and raised on the trailing part, the sense of rotation being anti-clockwise for right-handed threads and vice versa for left-handed threads. The pitch of the holes depends upon the size of the screw heads and the required clear distance between them. Provided the shank is heavier than the head, the screws are stated to fall into place satisfactorily in about five to six minutes.

CONTINENTAL AFFAIRS *(continued)*

Electrically-Operated Stabiliser Fin

BASED on the researches on stabiliser fins carried out by Dipl.-Ing. Franz Süberkrüb, Hamburg, the firms of Blohm and Voss and Siemens-Schuckertwerke have jointly developed a system of stabilisation by means of fins known as "Elektrofin." Compared with previous designs, the new system is claimed to incorporate the following innovations : The fins are driven by electric motors through gears. The bearing length of the fin is kept short and the span/chord ratio small, with the result that both size and weight of the fin installation are low, and the corresponding losses of buoyancy and carrying capacity are reduced. Moreover, the design does away with the need for a large diameter shaft seal for taking the fin trunnion into the interior of the hull. Because of its short length it has been found possible to accommodate the trunnion within the pocket into



A—Port fin.
B—Port fin housing.
C—Ward-Leonard set.
D—400 c/s motor generator set.
E—Port and starboard gearboxes.
F—Driving motors.
G—Cabinet housing gyroscopes, mixing panels, amplifier and switchgear.
H—Starboard fin housing.
J.—Starboard fin.

Arrow shows direction of travel.

Fig. 1—General arrangement of fin stabiliser with electrically controlled and operated fins

which the fin can be retracted. Only for the drive shaft has a small gland to be provided. This shaft, however, does not move axially but only carries out turning movements.

A typical installation is diagrammatically shown in Fig. 1, while Fig. 2 indicates the layout of the system, which is designed to reduce the ship's rolling motion, and also to correct heeling due to quasi-constant forces such as wind pressure and centrifugal force during turning.

In general, one pair of fins is employed, although in special cases there may be more than one fin on each side. Because of the small space needed, the port and starboard fins can be placed directly opposite each other even on small ships. The fins are either horizontal or inclined, depending upon the space available inside the hull.

In order to increase the damping effect, the larger size fins have an auxiliary flap, but this is omitted in the case of fins under 1 square metre. Lastly, a non-retracting version can be supplied if required. The fin is of welded construction and rotatably supported on its shaft in two bearings. The auxiliary flap is hinged to the trailing edge and is controlled by a lever in accordance with the movement of the fin itself. All bearings and sliders are of plastics materials and are lubricated by sea water.

The trunnion is a steel forging connected to two slide blocks which guide the fin during extension and retraction. At the same time, the slide blocks support the drive shaft and the drive of the auxiliary flaps. The piston rod and piston for the hydraulic extension and retraction movement are housed in a boring in the trunnion.

The angle of incidence of the fin is varied by an electric motor actuating the drive shaft through a three-stage reduction gearbox. The drive shaft operates the fin through a crank which engages with a slide to which the flap is linked in turn. The angle of incidence of the flap is always twice that of the fin itself. With this arrangement, the damping action is increased by 30 per cent.

The fin housing is fabricated from plate and fitted with guides for the sliders of the fin and with glands for the drive shaft. In order to prevent contact corrosion only steel and plastics materials are employed.

In addition the trunnion is given a protective coating. Those parts of the mechanism exposed to sea water consist of corrosion-resistant chrome alloy steel.

The installation is operated and controlled from the bridge. On pressing a push-button the fins are automatically extended and put into operation. Extension is carried out by a hydraulic pump unit and takes about two minutes.

A Ward-Leonard set is used to supply the driving motors which apply opposite angles of incidence to the two fins. Gyroscopes measure the angle of roll as well as roll velocity and acceleration, and these measurements are converted into electric signals. These are then combined into a single signal which, after amplification, is compared with the signal from the fin indicating the actual position, the difference being continually reduced to zero by the follow-on action of the motors. All control and regulating devices operate on alternating current of 400 c/s.

Shutting-down is also controlled by a push-button. The fins are turned back into the zero position, retracted, and locked, and the controls and driving motors are switched off. In case of a power failure the fins can be zeroed by hand and retracted by means of a hand pump. For testing and checking purposes the fins can be brought into any position by manually setting the control to the angle required.

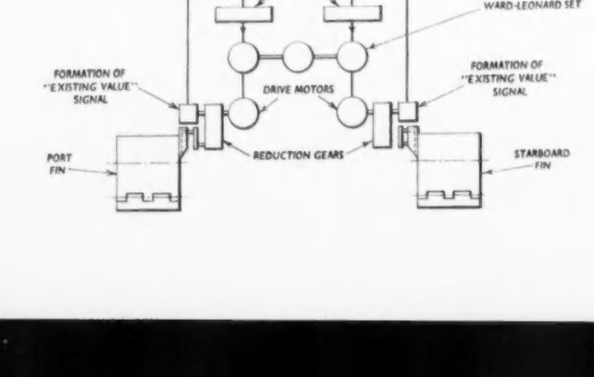
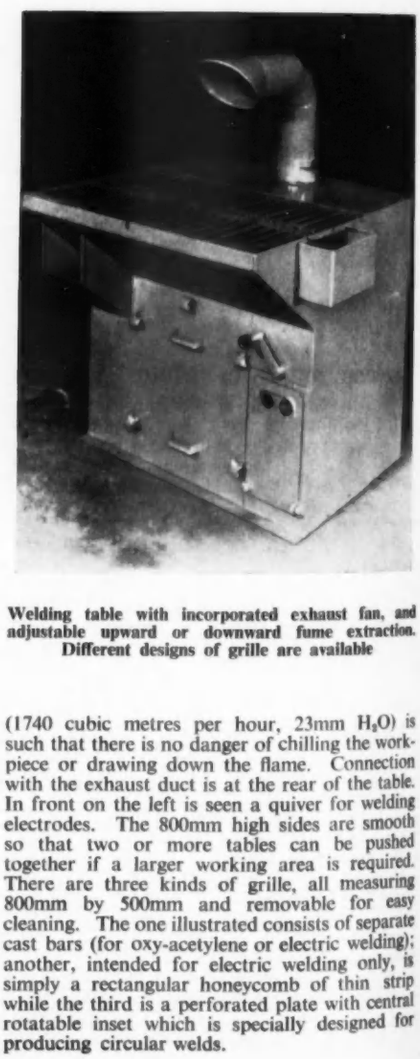


Fig. 2—Diagram showing fin drive and controls

Welding Table

We have received details of an improved welding table made by VEB Giesserei und Maschinenbau Zittau, Goethestrasse 12, Zittau, German Democratic Republic. The equipment is shown in the accompanying illustration. The table is equipped with a completely built-in, and therefore protected, extraction fan which extracts the fumes downwards through the grille, or upwards through the adjustable extraction nozzle, or by a combination of the two, the proportions being controlled by a flap. If desired, the air velocity can be increased by partially covering the grille. The normal exhaust



Welding table with incorporated exhaust fan, and adjustable upward or downward fume extraction. Different designs of grille are available

(1740 cubic metres per hour, 23mm H_2O) is such that there is no danger of chilling the workpiece or drawing down the flame. Connection with the exhaust duct is at the rear of the table. In front on the left is seen a quiver for welding electrodes. The 800mm high sides are smooth so that two or more tables can be pushed together if a larger working area is required. There are three kinds of grille, all measuring 800mm by 500mm and removable for easy cleaning. The one illustrated consists of separate cast bars (for oxy-acetylene or electric welding); another, intended for electric welding only, is simply a rectangular honeycomb of thin strip while the third is a perforated plate with central rotatable inset which is specially designed for producing circular welds.

THE AMERICAN SCENE

By Our American Editor

Submarine Developments

THE recent occurrences at the Holy Loch in Scotland, following the arrival of the American tender vessel " Proteus," have caused considerable public interest in the current and future submarine developments of the U.S. Navy. In the hold of the " Proteus," besides stores enough to supply a squadron of atomic submarines, is an undisclosed number of reserve " Polaris " missiles, the deadly, long-range weapons which overnight have propelled the lowly submarine into the front rank of U.S. deterrent strategy. The current " crash programme " to create ballistic-missile-launching submarines able to cruise anywhere in the world's oceans for weeks at a time proved successful five years ahead of schedule, when the " George Washington " returned last January from somewhere in the North Atlantic. For sixty-seven days she had kept sixteen key Eurasian land targets in her sights and " her finger on the trigger," packing in sixteen " Polaris " launching tubes a force more devastating than all the bombs dropped in World War II. Such an exploit inevitably has given new impetus to American submarine development. To-day the U.S. Navy is spending some 150 million dollars a year on construction of so-called attack submarines and 525 million dollars a year to build " Polaris " ships. Another 50,000,000 dollars annually is going into the modernisation of conventional submarines, and 100 million dollars into maintenance and repair. Research and development costs bring the current total undersea warfare expenditures to no less than 1000 million dollars a year. Moreover, the continuing threat of obsolescence in a world menaced by war assures that these outlays will rise rather than fall in the years to come.

The converted " Proteus " is only the first of perhaps eight or nine new tender ships, with all the rest to be built from the keel up. Hard at work building the submarine force, and anticipating further orders in the future, is a sizeable group of U.S. firms. Currently holding contracts for nuclear submarines are the Ingalls Shipbuilding Company, the New York Shipbuilding Corporation, the Newport News Shipbuilding and Dry Dock Company, and the Electric Boat division of the General Dynamics Corporation. Hull construction and other outfitting managed by the shipyard represents from one-third to one-half of the total cost of a modern submarine. Varying from ship to ship, the bulk of the additional cost is divided among suppliers of nuclear propulsion equipment, electronics and guidance gear, atmospheric and " habitability " machinery, weapons, periscopes and other large components for which the service contracts directly. The major producers of reactors and related power plant are Westinghouse Electric, General Electric, Combustion Engineering, Babcock and Wilcox, Alco Products, Foster Wheeler and DeLaval.

Basically, the U.S. Navy to-day operates two classes of undersea boats : " attack " submarines and " Polaris " type submarines, fundamentally as different as were destroyers and aircraft carriers in the last war. On active duty in the attack category are ninety-three conventional, diesel-powered submarines, nearly all built during World War II. By next year, however, on the basis of their designated lifespan of seventeen years, over fifty will be ready for retirement, and soon thereafter, the rest will sink into obsolescence. The attack fleet, at the moment, also comprises twelve nuclear-powered submarines of which the oldest, " Nautilus," was launched more than seven years ago ; three more soon are to be commissioned.

In order to maintain strength at the arbitrary limit of 108 attack submarines authorised by Congress, the U.S. Navy has set aside funds for construction of another fourteen of the nuclear vessels. All of these will be on active duty by 1964. Congress has authorised an official maximum of forty-five " Polaris " submarines. Of that total, three have joined the Fleet and two more will do so shortly ; another four will be commissioned during the fiscal year 1962. Finally, ten others are under construction in the shipyards. Such figures suggest that until lately, submarine construction had been lagging behind the rate needed to fend off obsolescence. Indeed, from 1948 till 1955, only eighteen submarines of all classes were authorised—an average of little more than two a year, as compared with at least six required just to keep the undersea fleet up to date. Moreover, only three of the eighteen were nuclear vessels. Since 1955, the average has picked up, to exactly seven new vessels a year, with the emphasis on the atomic-powered type. With the further speed-up recently ordered by President Kennedy, thirty-two nuclear submarines, in one stage or another, are on the way to join the sixteen now in the Fleet.

Whatever the actual number of submarines on the way, more important is the rapidly progressing technology of building and outfitting them. Of all the contributions of this sort, probably none is more significant than the development of the " Polaris." Under the driving leadership of Vice Admiral Wm. F. Raborn, the first of these missiles was fired successfully last summer, five years ahead of schedule. Incorporating major breakthroughs in solid-fuel propulsion, inertial guidance and reduction in size of the nuclear warhead, the " Polaris " can travel with pinpoint accuracy from anywhere in the ocean, on a ballastic range of up to 1200 miles. " Follow-on " versions are now in development to increase the range to 1500 and then to 2500 miles. What is more, Lockheed has designed the weapon so skilfully that it can be operated under difficult conditions by a ship's complement of something like 100 men, nearly all of whom are involved mainly in running the ship.

In atomic reactors, too, recent technical progress has been remarkable. Under the stern guidance of Admiral Hyman G. Rickover, the engineers at Westinghouse and General Electric created from the massive prototypes of the early 'fifties a power plant little larger than modern diesel equipment. Not only does the reactor permit a submarine to dive deeper, stay submerged longer and travel faster and more quietly underwater, but its presence aboard ship also makes available an excess of power with which to run the complex ancillary equipment. In trials, submarine reactors have operated at or near full steam without refuelling for nearly 100,000 miles. Perhaps even more significant, not a single case of radiation sickness or other reactor-caused discomfort has been reported. To date, over sixty reactors for marine propulsion, nearly all for submarines, have been built and ordered—many times the number for non-experimental, land-based installations.

The new submarines virtually are floating data-processing centres and ultra-sensitive listening posts. Since the war, the sonar ranges in shipboard equipment are said to have been increased 400 per cent. Highly sensitive, retractable radio antennae and the most advanced radar receiving equipment available continue to go aboard every submarine as auxiliaries and for use in friendly ports. The Sperry-Burroughs " Shipboard Inertial Navigation System," which is standard on " Polaris " submarines and adapted for other nuclear boats as well, has no parallel on any manned vehicle to-day. The system adjusts for speed and direction without resort to such traditional aids as the stars, continuously plotting its precise position even during an extended trip under the earth's magnetic poles. Last year, the " Triton," in retracing Magellan's trip around the world, covered 41,500 miles in eighty-four days without surfacing.

Of great interest, too, is some of the atmosphere-controlling apparatus. Conventional submarines, though they carry bottles of compressed oxygen, as well as carbon dioxide cleansing equipment, must surface—or at least snorkel—every few hours. The feat of travelling ninety, or even thirty, days without coming up for air represents a considerable achievement. Actually, the air in a submarine from beginning to end of its cruise far exceeds in purity any found naturally on earth. On older submarines, oxygen is supplied from space-consuming racks of bottles. Meanwhile, carbon dioxide is removed continuously by Girdler units, one each aboard conventional submarines and two on the nuclear ones. Special chemicals also are kept on hand for emergency CO_2 removal and oxygen generation. The newer vessels use a high-pressure electrolytic generator built by Treadwell, which ionises water to produce oxygen and hydrogen. In time, however, the stored-up and compressed hydrogen, like the carbon dioxide residue of a scrubber, must be thrown overboard. Since pressurising the

THE AMERICAN SCENE *(Continued)*

gas is difficult and very noisy when the submarine is running deep, this creates something of a problem. It may be overcome by a new unit which Ionics Incorporated is developing for the U.S. Navy's Bureau of Ships. Here oxygen generation and CO_2 scrubbing would be handled by a single apparatus less than half the size of the present gear. Using distilled sea water the system produces four chemical " streams "—hydrogen, oxygen, an alkaline solution and one of acid. A CO_2 effluent is removed from the alkaline solution and mixed with the acid to regenerate the power cell and produce pure CO_2 at the same time. The latter is combined with the hydrogen to produce a relatively small volume of hydrocarbons, which can be stored conveniently for long periods. To pursue this research, Ionics has set up a new environmental testing centre in which a one-man sealed chamber is to be occupied continuously by one or another of its personnel.

Some of the less dramatic but more important contributions to the modern submarine have come from the shipyards themselves. Electric Boat, for example, has been largely responsible for the evolution of nuclear submarine architecture ; its yards have built the prototype of every model now afloat. Oddly enough this evolution has followed a cyclical pattern dating from the first " true submersible," built in 1900 by the pioneers John Holland and Simon Lake. Its most striking characteristic was a whale-like shape. In World Wars I and II, however, the designers made submarines look more and more like surface ships—flat-decked with guns and other equipment protruding everywhere—because they were expected to travel as well as fight, mostly on the surface. With the " Nautilus " and the " George Washington," both converted from conventional designs, the streamlined configuration returned ; in the newest models, " Thresher " and " Lafayette," whale-like styling is once again evident. On the surface, these ships are slower and far less seaworthy than when submerged. Their one outer protuberance, the conning tower, has been fitted out with planes to resemble quite closely an aircraft tail assembly.

Altogether the evidence is now fairly conclusive that the Kennedy Administration and a defence-minded Congress will give increased impetus to the submarine programme. Thus, to follow up the converted " Proteus," Newport News has received a contract to build a second nuclear submarine tender. Then, too, the construction of experimental submarines appears to have become a permanent programme. The U.S. Navy now has a diesel-powered craft—the " Albacore "—on constant duty as a testing laboratory for new ideas. A second such craft, in the design stage, is an ultra-deep diver, aimed at perfecting plunges to the bottom. Finally, a related project may get under way at Reynolds Metals, which has a contract to study design data for an aluminium-clad submarine. The Office of Naval Research believes that, while such a vessel might need supplemental steel in the hull to enable it to withstand the pressures of the deep, it would represent progress towards the ideal of neutral buoyancy. In sum, as all this activity suggests, the submarine is moving under a full head of steam to take its place in the very front rank of America's deterrent strategy.

High-Energy Electric Arc Heater

A MACHINE with the potential capability to supply a stream of gas at temperatures as high as 20,000 deg. Fah. and pressures as great as 15,000 lb per square inch has been devised by the Westinghouse Electric Corporation. The machine is an electric arc heater and can operate for sustained periods of time and at an extremely low level of gas contamination. The arc heater has immediate application in a wind tunnel for missile testing. Also, it holds promise as a chemical synthesiser and as a furnace for processing metals with ultra-high melting point. A prototype model of the machine has been operated at a power input of 1700kW, but may go up to 30,000kW. Already, the temperature into the nozzle has been maintained at 10,000 deg. Fah., and, in addition, the flow from the nozzle of the unit has reached a sonic velocity of 3400 miles per hour. Velocities over ten times the speed of sound can be expected when the gases are expanded with a hypersonic exhaust nozzle. Applying these characteristics to a wind tunnel will help to duplicate the extreme conditions met by missiles and other space craft of the future upon re-entry into the earth's atmosphere. As a chemical synthesiser, the machine will supply the high temperatures necessary for inducing difficult chemical reactions. Nitrogen and oxygen, for instance, could be combined in the heat chamber to form nitrous oxide. A synthesiser of this type could also find application in processing petroleum products. The potentialities of the unit as a furnace might make a number of refractory metals available in ingot form for the first time. Normally used in powder form, metals such as tungsten are difficult to process because of their high melting points. In all these applications, the success of the arc heater is greatly dependent upon a low level of contamination. One of the problems involved in units under development during the past two years is that electrodes and walls of the chamber burn and thus contribute impurities amounting to as much as 10 per cent of the mass of the gas flowing through the system. The new unit has a guaranteed maximum contamination level of 0·2 per cent, and still further reductions in this level are contemplated. In addition, the Westinghouse arc heater has a uniform temperature " profile " within the heat chamber. A diagram of the unit is reproduced above.

The basic concept for the new arc heater was proposed by Dr. Werner Emmerich, of the Westinghouse research laboratories. He conceived a scheme in which an electric arc, dissipating megawatts of electric power, can be maintained for prolonged periods of time to transfer thermal energy continuously to a gas passing through the arc. This is done virtually without erosion of the electrodes, thus all but eliminating this cause of gas contamination. A key to the performance of the new machine lies in the design of the two electrodes which form the terminals for the arc. Each of these electrodes consists of a hollow doughnut-shaped ring placed horizontally, one directly above the other. Water is pumped through the hollow rings to cool them. An electric arc is started by drawing it across the gap between the two rings, and then rotated around the gap at high speed. The rotation of the arc is accomplished by a magnetic field from d.c. coils arranged around the outside of the heat chamber. This rotation, combined with water-cooling, prevents the electrodes from heating to a point beyond the structural endurance of the material. Repeated tests of the unit have left the electrodes undamaged, indicating a lack of contamination from this source. The working fluid, such as air or nitrogen, enters the arc chamber and passes into the arc through openings near a water-cooled copper heat shield. This shield, which can withstand arc temperatures well above 10,000 deg. Fah. without eroding, protects the walls of the arc chamber. After leaving the arc, the fluid passes through a water-cooled nozzle.

Diagram of Westinghouse high-energy electric arc heater

The prototype arc heater was designed to accommodate a 1·2 lb per second flow of either air or nitrogen. The unit should be able to supply gas at 1500 lb per square inch with a constant enthalpy of more than 2000 B.Th.U. per lb for as long as 10 minutes without damage or measurable gas contamination. The efficiency of heat transfer to the gas is in excess of 50 per cent.

More than 50 tests of the prototype arc heater have been successfully completed, and testing will continue until the design limits of the equipment have been verified. So far, the highest pressure at which tests have been conducted is 730 lb per square inch. Other tests with a power input of 549V and 5046A, or 9450kW per lb per second, have raised the enthalpy of air passing through the chamber to 4670 B.Th.U. per lb. The equipment can use either direct or alternating current, single or three-phase. The arc heater was developed by Westinghouse specifically for use as a high-temperature air supply for the study of missile re-entry problems. A variation of the prototype model is now available to the aircraft industry for this application.

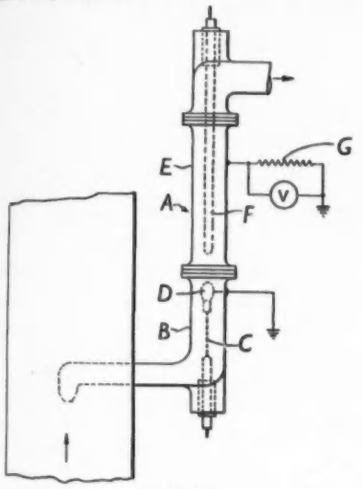
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

SMOKE DETECTION

862,147. May 20, 1957.—APPARATUS FOR SMOKE DETECTION, Associated Electrical Industries, Ltd., 33, Grosvenor Place, London, S.W.1. (*Inventor : Duncan Holmes Grindell.*)

The invention relates to means for detecting smoke particles in a gaseous flow by detecting the electric charge derived from the particles. Referring to the drawing a chimney has a small fraction of the smoke sucked through a test section, *A*. The test section comprises a duct, forming a first chamber, in this case a short straight tube *B*, surrounding a central wire electrode *C* to which a high negative potential is applied through a conductor sealed in the wall of an elbow portion. The upper end of the wire is suspended from a trap electrode *D*. The trap



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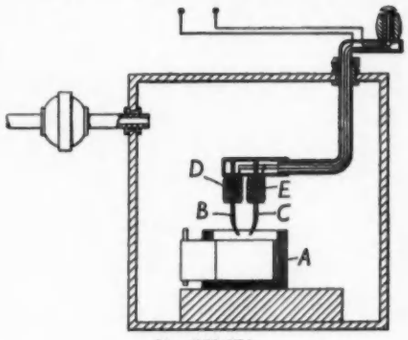
electrode and the wall of the chamber are connected together and earthed. A second chamber *E* of the duct is formed by a longer tube ; an insulating gasket being arranged between the tube flanges. A central electrode *F* extending into chamber and having a substantially greater diameter than the wire *C* is suspended from an elbow which is connected to the tube by means of flanges insulated by gasket. The electrode *F* is supplied with a high negative potential, which is less than the potential on electrode *C*. The wall of tube *E* which acts as a collector electrode is connected to earth through a load resistor *G* having a voltmeter arranged in parallel circuit relationship. It will be understood that the voltmeter will indicate the rate of charge transfer to the wall of tube *E* as the solid particles are discharged. The voltmeter can be calibrated to read smoke content, as the electric charge is carried on the particle surface, and the size of the particles is approximately constant, so that the current and voltage caused by the integrated particle charges are a measure of the total of solid charged particles sampled per unit time, i.e. the smoke content. A modified arrangement of the device is also described in detail.—*March* 1, 1961.

HANDLING EQUIPMENT

862,174. June 12, 1956.—DEVICE FOR REMOTE CONTROL, MOVEMENT, OR HANDLING OF AN OBJECT, Rolls-Royce Limited, Nightingale Road, Derby. (*Inventor : John Graham Swinton Biram*).

This invention relates to a device for remote control, movement, or handling of an object. An object of the invention is to provide a device which can be controlled at a distance from the object to be controlled, moved, or handled, the device not forming part of the object. According to the invention a member of a device, for controlling, moving or handling an object has a bi-metallic part which, on change of temperature, is deformed to engage or disengage the object. The deformation of the bi-metallic part may be controlled by an electric heating coil having a remotely controlled current supply. The drawing shows a diagrammatic section through one embodiment of the invention, and in it a vacuum chamber has a platform on which rests a furnace *A*. The device is employed, in this instance, for handling articles within the furnace and for removing them to the platform. A pair of members *B*, *C* are supported in a holder carried by a support tube extending outside the chamber. The members *B*, *C* are each made in the form of laminated bi-metallic strips. Around each member is an electric heating coil *D*, *E*, the coils being connected in parallel to wires leading to a switch which may form part of a handle by which the device is gripped manually for



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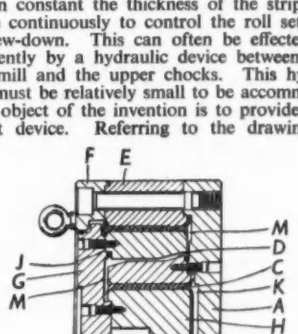
operation. In operation the device is adjusted by sliding and rotating the support tube in the bush to bring the members into a position where they straddle the object to be handled. The switch is then closed so as to complete the electric circuit through the coils and heat the bi-metallic members which bend towards one another and to grip the object. When the switch is opened the members cool, for their ends move apart to release the object.—*March* 1, 1961.

ROLLING MILLS

862,743. May 1, 1957.—PRESSURE APPLYING OR RESPONSIVE MEANS, The British Iron and Steel Research Association, 11, Park Lane, London, W.1. (*Inventors : Arthur Conway, Samuel Skipton Carlisle and Wilfred Cecil Frederick Hessenberg.*)

In a previous Specification No.692,267, there was described an automatic system for rolling mills in which the setting is automatically controlled, to maintain constant the thickness of the strip. It is possible continuously to control the roll setting by the screw-down. This can often be effected more conveniently by a hydraulic device between screws of the mill and the upper chocks. This hydraulic means must be relatively small to be accommodated and an object of the invention is to provide such a compact device. Referring to the drawings, the



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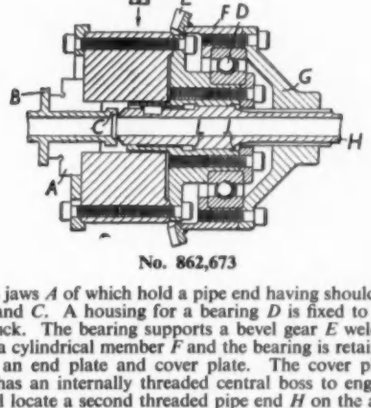
device comprises two movable assemblies. One such assembly has a disc-shaped base plate *A* to which is attached centrally an annulus *B* forming a first chamber *C*. An annular second chamber *D* is formed between this and a second annulus formed in two separate parts *E* and *F*, attached to the base-plate. The second assembly also has a disc-shaped baseplate *G* receivable within the part *F* of the second annulus and having attached thereto a central piston *H* located within the chamber of cylinder *C*. The part *F* has an inwardly projecting lip which overlaps an outer edge of the baseplate *G* to limit the relative outward movement of the two assemblies. An annular surrounding member *J* is also attached to the baseplate *G* and is received within the cylinder *D*. This pressure applying device is compact and can be easily placed between the roll chocks and the screw of a rolling mill. The piston *H* is bonded to the inner side of annulus *B* by a thick layer of rubber. A similar layer of rubber is bonded between the outer side surface of annular member *J* and the inner side of annular member *E*. The rubber is moulded with ridges which are compressed by the surfaces on plates *A* and *G*, to seal the junctions. When assembled, the device includes two pressure chambers. One *K*, at the head of piston *H* is sealed off by rubber apart from a channel *L*. The other chamber *M* is formed in two sub-chambers, one located at the head of member *J* and the other between plate *G* and the head of annular member *B*. The two parts of chamber *M* are in communication through the ring channel between annulus *B* and the inner side surface of annulus *J*. There is a channel similar to channel *L*, for connecting the chamber with a source of pressure ; otherwise the chamber *M* is sealed off by the rubber. Where the device is used in a rolling mill, it is located between a roll chock and the corresponding screw. The screw-down is adjusted until the rolls are approximately adjusted for the rolling operation. Chamber *M* is filled with oil and connected to a hydraulic accumulator. As the screw-down of the rolls is increased, the pressure is built up in chamber *M* so that when the screw-down is fixed this pressure varies little for small changes in the relative position of the plates *A*, *G*. This chamber and the accumulator form a liquid spring. The second chamber is connected to a supply of high pressure oil through a regulating valve controlled by the separating force of the workpiece on the rolls, and the roll setting, so as to adjust the roll setting to maintain constant the thickness of the work.—*March* 15, 1961.

PIPES

862,673. June 26, 1959.—PIPE COUPLINGS, United Kingdom Atomic Energy Authority, London. (*Inventor : William Paul White.*)

This invention is intended to provide a demountable pipe coupling which is suitable for operation from remote positions. The drawing shows a pipe holder in the form of a conventional lathe scroll chuck,



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the jaws *A* of which hold a pipe end having shoulders *B* and *C*. A housing for a bearing *D* is fixed to the chuck. The bearing supports a bevel gear *E* welded to a cylindrical member *F* and the bearing is retained by an end plate and cover plate. The cover plate *G* has an internally threaded central boss to engage and locate a second threaded pipe end *H* on the axis of the first pipe. The pipe *H*, which is keyed to the housing but free to move axially, has a conical seat and shoulders at its end. The chuck is operated in the normal manner by the bevel gear. To make a union between the pipe ends, the bevel gear is rotated to rotate the member *F* and plate *G* in a direction to move the pipe end *H* from left to right until the shoulder *J* abuts the end plate. With the chuck jaws open the end of the first pipe is inserted in the chuck so that the shoulder *B* abuts the outer face of the jaws (as shown in the drawing). The jaws are then closed to centralise the assembly and hold the pipe end against rotation. The bevel gear is then rotated in the opposite direction to move the pipe end *H* until its conical seat contacts the first pipe end. Further rotation of the gear forces the pipe end through the jaws until the shoulder *C* abuts the inner face of the jaws and then tightens the coupling to make a joint. The shoulder *L* limits the travel of pipe *H* when the other pipe is not *in situ*. The outer and inner faces of the jaws limit the axial movement *B* and *C*. The coupling is stated to be suitable for use in pipelines carrying gases or liquid metals at elevated temperatures up to at least 300 deg. Cent. The coupling may be broken by reversing the procedure described and the parts removed and remade in a different location by remote control.—*March* 15, 1961.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Today, April 7.—LIVERPOOL AND DISTRICT BRANCH: Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, Films, 7.30 p.m.

Mon., April 10.—BOLTON BRANCH: Railway Hotel, Trinity Street, Bolton, "Fire Alarm Systems," A. Whitehouse, 7.45 p.m. ★ ESSEX BRANCH: Angel Hotel, Broadway, Ilford, Essex, Chairman's Invitation Lecture, 8.15 p.m. ★ LEEDS BRANCH: Great Northern Hotel, Leeds, "The Aims and Objects of the N.I.C.E.I.C.," E. J. Sutton, 7.30 p.m. ★ CENTRAL LONDON BRANCH: White Hall Hotel, Bloomsbury Square, London, W.C.1, "Railway Electrification," 7.15 p.m. ★ NORTH WEST LONDON BRANCH: Century Hotel, Wembley, "Transistors and Other Semiconductor Devices," D. D. Jones, 8.15 p.m. ★ SHEFFIELD BRANCH: Royal Victoria Hotel, Sheffield, "Heavy Industrial Control Gear," C. V. Curran, 7.30 p.m.

Tues., April 11.—CHESTER AND DISTRICT BRANCH: Westminster Hotel, City Road, Chester, "Electric Floor-Warming and Allied Applications of Heating Cables," K. W. Ballamy, 7.45 p.m. ★ PORTSMOUTH AND DISTRICT BRANCH: Committee Rooms, Ministry of Labour Offices, Lake Road, Portsmouth, "Signalling and Control System as Used by London Transport," 7.30 p.m.

Wed., April 12.—BIRMINGHAM BRANCH: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, "Medium Voltage Distribution Gear: Current Practice and Future Trends," J. H. Rowley, and J. R. Watkin, 7.30 p.m. ★ LUTON BRANCH: College of Technology, Park Square, Luton, "Closed Circuit Television," 8.15 p.m.

Thurs., April 13.—BRADFORD AND DISTRICT BRANCH: Midland Hotel, Bradford, "Eddy-current Controlled Slip Couplings as Drives and Tension Brakes," R. H. Wheat, 7.30 p.m. ★ OXFORD AND DISTRICTS BRANCH: Reactor School, A.E.R.E. Harwell, "Radio-Astronomy," A. D. Petford, 5.45 p.m.

BRITISH HYDROMECHANICS RESEARCH ASSOCIATION

Mon. to Wed., April 17 to 19.—Grosvenor Hall, Conference Centre, Ashford, Kent, International Conference on "Fluid Sealing."

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., April 12.—ELECTRO-ACOUSTICS GROUP: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Vibration Analysis and Testing," D. E. Mullinger, 6 p.m. ★ NORTH EASTERN SECTION: Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, Annual General Meeting, and "Colour Television," G. N. Patchett, 6 p.m.

COVENTRY ENGINEERING SOCIETY

Thurs., April 13.—Social Club, Coventry Victor Motor Company, Ltd., Ford Street, Coventry, "Some Modern Methods of Producing Close Tolerance Light Alloy Castings," Mr. Pendleton, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., April 10.—SHEFFIELD CENTRE: Grand Hotel, Sheffield, Annual General Meeting, and Lighting Forum, 6.30 p.m.

Thurs., April 13.—MANCHESTER CENTRE: Demonstration Theatre, North Western Electricity Board, Town Hall Extension, Manchester, 2, Annual General Meeting, and Papers by W. Carlton, G. Mawson and J. E. Tonge, 6 p.m.

Mon., April 17.—LEEDS CENTRE: British Lighting Council, 24, Aire Street, Leeds, 1, "The Artistic Use of Lighting in Multi-Camera Technique," N. E. H. Mayhew, 6.15 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., April 13.—BEDS. AND HERTS. SECTION: W. H. Allen, Sons and Co., Ltd., Bedford, Annual General Meeting, and Quiz, "Fault and Cure," 7.30 p.m.

Tues., April 11.—SLOUGH SECTION: Lecture Theatre, High Duty Alloys, Ltd., Slough, Annual Meeting, and Films, 7.30 p.m.

INSTITUTE OF METALS

Wed., April 12.—LEEDS METALLURGICAL SOCIETY: University Staff House, University Road, Leeds, "Some Aspects of the Metallurgy of Fasteners," R. J. Allsop, 6.30 p.m.

Thurs., April 13.—EAST MIDLANDS METALLURGICAL SOCIETY: Derby and District College of Art, Derby, Annual General Meeting, and "Recent Work on Cold Forming and Extrusion," N. S. Angus, 7.30 p.m.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

To-day, April 7.—Brunel College of Technology, Acton, London, W.3, Symposium on "Electrical Contacts," to be held in collaboration with the Institution of Electrical Engineers.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, April 7.—SOUTH WALES CENTRE: Grand Hotel, Cardiff, Annual General Meeting, 7.15 p.m.

Mon., April 10.—MANCHESTER AND DISTRICT CENTRE: Whitworth Room, Second Floor, Engineers' Club, Albert Square, Manchester, Annual General Meeting, 7.30 p.m. ★ SCOTTISH CENTRE: North British Hotel, Edinburgh, "Special Servicing Tools for Heavy Transport Vehicles," J. Blaber, 7.30 p.m.

Tues., April 11.—EASTERN CENTRE: White Hart Hotel, Newmarket, Annual General Meeting, 7.30 p.m.

Wed., April 12.—SOUTHERN CENTRE: Palmeira Hotel, Hove, Annual General Meeting, 7.30 p.m.

Thurs., April 13.—MANCHESTER AND DISTRICT CENTRE: Visit to the British Belting and Asbestos Company, Ltd., Cleckheaton, Yorkshire.

INSTITUTE OF WELDING

Tues., April 11.—LIVERPOOL AND DISTRICT BRANCH: City of Liverpool College of Technology, Byrom Street, Liverpool, 3, Annual General Meeting and Film Show, 7.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., April 11.—Society of Chemical Industry, 14, Belgrave Square, London, S.W.1, Joint meeting with the Chemical Engineering Group, "A Systematic Classification of Chemical Processes and Equipment," K. Fischbeck, 6 p.m.

Wed., April 12.—MIDLANDS BRANCH: Chemical Engineering Department, The University, Edgbaston, Birmingham, 15, One-day Symposium on "Materials of Construction," 9.30 a.m. to 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., April 11.—Great George Street, Westminster, London, S.W.1, "Recent Works on the Canal System of B.T.C. and Planning of the Future," B. H. Tripp, 5.30 p.m.

Thurs., April 13.—GRAHAM CLARK LECTURE: Great George Street, Westminster, London, S.W.1, Joint meeting with the Institution of Electrical and Mechanical Engineers, "Resources, Human and Material, of the Commonwealth," H.R.H. The Prince Philip, Duke of Edinburgh, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., April 10.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, Discussion on "Applications of Electrical Phenomena at Liquid Helium Temperatures," opened by R. E. Hayes, 5.30 p.m. ★ MERSEY AND NORTH WALES CENTRE: Royal Institution, Colquitt Street, Liverpool, Annual General Meeting, and "The Mechanism of Lightning," J. M. Meek, 6.30 p.m. ★ NORTH-EASTERN MEASUREMENT AND ELECTRONICS GROUP: Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, Annual General Meeting, and "Some Aspects of the Application of Electronics to Medicine," F. T. Farmer, 6.15 p.m. ★ SOUTH MIDLAND CENTRE: College of Technology, Gosta Green, Birmingham, Joint meeting with the Supply and Utilisation Group, "Development of 'Off Peak Heating' with particular reference to Floor Warming," S. C. Dinenage, 6.30 p.m. ★ WESTERN CENTRE: The University, Bristol, "Speed Changing Induction Motors—Further Developments in Pole-Amplitude Modulation," G. H. Rawcliffe, 6 p.m.

Tues., April 11.—MEASUREMENT AND ELECTRONICS SECTION: Savoy Place London, W.C.2, "Precision Instruments for Coaxial Line Measurements up to 4 Gc/s," D. Woods, and "The Concept of Equivalent Source, E.M.F. and Equivalent Available Power in Signal-Generator Calibration," D. Woods, 5.30 p.m. ★ EAST MIDLAND CENTRE: Lecture Theatre, Portland Building, The University, Nottingham, "The Power Drive and Control for Jodrell Bank Radio Telescope," O. N. Kington, H. A. Prime, and H. T. Price, 6.30 p.m. ★ NORTH MIDLAND CENTRE: Royal Station Hotel, York, "Some Notes on the Electrical Requirements of General Cargo Docks," E. R. Radway, 7 p.m. ★ NORTH-WESTERN CENTRE: Engineers' Club, Albert Square, Manchester, "The Impulse Strength of Impregnated-Paper Dielectrics as used in High-Voltage Cables," B. F. Salvage and J. A. M. Gibbons, 6.15 p.m. ★ NORTHERN IRELAND CENTRE: Civil Engineering Department, David Keir Building, Queen's University, Stranmillis Road, Belfast, 3, "Research on the Performance of High-Voltage Insulators in Polluted Atmospheres," J. S. Forrest, P. J. Lambeth and D. F. Oakeshott, 6.30 p.m. ★ SOUTHERN CENTRE: The University, Southampton, "High-Speed Pulse Techniques using Transistors," E. Wolfendale, 6.30 p.m.

Wed., April 12.—SUPPLY SECTION: Savoy Place, London, W.C.2, "The Calculation of the Magnetic Field of Rotating Machines—Part 2—The Field of Turbo-Generator End-Windings," D. S. Ashworth and P. Hammond, and "The Magnetic Field of the End-Windings of Turbo-Alternators," P. J. Lawrenson, 5.30 p.m. ★ EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Teaching Physics to Engineers," opened by J. Topping, 6 p.m. ★ LONDON GRADUATE AND STUDENT SECTION: Visit to Kodak, Ltd., Wealdstone, 2.30 p.m. ★ NORTH LANCASHIRE SUB-CENTRE: N.W.E.B. Lecture Theatre, Jubilee Street, Blackburn, "The Provision of Adequate Electrical Installations in Buildings—Small Industrial Premises," J. A. Sharp, 7.30 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Measured and Electrical Model Characteristics of Buildings Heated by Floor Thermal Storage," E. D. Taylor, B. Berger and G. Blaylock, 6 p.m. ★ SOUTH WESTERN SUB-CENTRE: Plymouth "B" Generating Station, Prince Rock, Plymouth, "The Logmotor—A Cylindrical Brushless Variable-Speed Induction Motor," F. C. Williams, E. R. Laithwaite, J. F. Eastham and L. S. Piggott, 3 p.m.

Thurs., April 13.—GRAHAM CLARK LECTURE: Institution of Civil Engineers, Great George Street, London, S.W.1, Joint meeting with the Institutions of Civil and of Mechanical Engineers, "Resources, Human and Material, of the Commonwealth," H.R.H. The Prince Philip, Duke of Edinburgh, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION: Savoy Place, London, W.C.2, Joint meeting with the Utilisation Section, "Aluminium in Electrical Engineering," P. J. H. Rata, "Diesel Railway Locomotives," A. D. Swanston and B. W. Towell, and "Automatic Programmes for Hot Reversing Mills," T. E. S. Rickard, 6 p.m. ★ NORTH LANCASHIRE SUB-CENTRE: N.W.E.B. Demonstration Theatre, Duke Street, Barrow, "The Provision of Adequate Electrical Installations in Buildings—Small Industrial Premises," J. A. Sharp, 7.30 p.m. ★ NORTH SCOTLAND SUB-CENTRE: Electrical Engineering Department, Queen's College, Dundee, "Some Considerations in the Application of Power Rectifiers and Converters," J. P. McBreen, 7 p.m. ★ WEST WALES (SWANSEA) SUB-CENTRE: Conference Room, S.W.E.B., The Kingsway, Swansea, "The Determination of the Electrical Characteristics of an Arc Furnace," J. Ravenscroft, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., April 10.—NORTH STAFFORDSHIRE BRANCH: North Staffordshire Technical College, Stoke-on-Trent, Annual General Meeting, and Film Show, 7.15 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., April 12.—Kent Room, Caxton Hall, London, S.W.1, "Use of Isotopes in Industry," J. P. Frampton, 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., April 11.—39, Elmbank Crescent, Glasgow, Annual General Meeting, and "Cavitation Tunnel Tests with Merchant Ship Propellers," H. B. Lindgren, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, April 7.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "Standards of Design for Rural Roads," I. A. Cramm, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, and Sat., April 7 and 8.—NORTHERN IRELAND GRADUATES' SECTION: Visit of the Scottish Graduates' Section to Belfast.

Sat., April 8.—EASTERN GRADUATES' BRANCH: Visit to I.C.I. Paints, Stowmarket, 9.30 a.m.

Mon., April 10.—NORTH-EASTERN BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, Annual General Meeting, and Repetition of the Nominated Lecture, "The Inspection of the Primary Circuits and Reactor Pressure Vessels of Nuclear Power Plant," H. N. Pemberton and E. Crossley, 6 p.m.

Tues., April 11.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, "Application of the Flash Temperature Concept to Cam and Tappet Wear Problems," A. Dyson and H. Naylor, 6 p.m. ★ NORTH EASTERN BRANCH: Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, Repetition of the Nominated Lecture, "The Inspection of the Primary Circuits and Reactor Pressure Vessels of Nuclear Power Plant," H. N. Pemberton and E. Crossley, 6 p.m. ★ WESTERN BRANCH: Engineering Laboratories, The University, University Walk, Bristol, "The Potentialities of Accurate Control and Measurement in Engineering Manufacture," J. Loxham, 7 p.m.

Wed., April 12.—ORDINARY MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, "Surface Contact in Theory and Practice," F. T. Barwell, 6 p.m. ★ YORKSHIRE GRADUATES' SECTION: Afternoon Visit to Parkgate Iron and Steel Works, Rotherham, Yorkshire.

Thurs., April 13.—GRAHAM CLARK LECTURE: The Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Joint meeting with the Institutions of Civil and of Electrical Engineers, "Resources, Human and Material, of the Commonwealth," H.R.H. The Prince Philip, Duke of Edinburgh, 5.30 p.m. ★ EAST MIDLANDS BRANCH: College of Technology and Commerce, Room 104, Leicester, Annual General Meeting, and Repetition of the Thomas Hawkesley Lecture, "The Effect of Nuclear Radiation on Engineering Materials," A. H. Cottrell, 7 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., April 11.—MANCHESTER BRANCH: Manchester Literary and Philosophical Society's Rooms, George Street, Piccadilly, Manchester, "Welding," F. Koenigsberger, 7.15 p.m.

Wed., April 12.—EAST MIDLANDS BRANCH: Sherwood Room, County Hotel, Theatre Square, Nottingham, Members' 10-minute papers, 7 p.m. ★ WESTERN BRANCH: Grand Hotel, Broad Street, Bristol, "Electricity Supply and Distribution in Factories," C. H. J. Bax, 7.15 p.m.

Thurs., April 13.—GLASGOW BRANCH: Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2, "Plant Records," 7.15 p.m. ★ NORTH EAST BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, 1, "Modern Welding Processes," J. A. Lucey, 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., April 12.—NORTH MIDLANDS REGION: Works Visit to Yorkshire Imperial Metals, Ltd., Stourton, near Leeds, 10.30 a.m. ★ NORTH WESTERN REGION: Exchange Hotel, Tithebarn Street, Liverpool, 1, "New Materials in Industry—Plastics," E. M. Elliott, 7.30 p.m. ★ SOUTH EASTERN REGION: Ilford Conservative Club, 42, High Road, Ilford, "Chemical and Electrolytic Surface Finishes," D. Read, 7.30 p.m.

Thurs., April 13.—LONDON GRADUATE SECTION: Works Visit to Albert E. Reed and Co., Ltd., Aylesford Paper Mills, Lackfield, near Maidstone, Kent, 9.30 a.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, April 7.—GRADUATES' AND STUDENTS' SECTION: Engineering Centre, Stephenson Place, Birmingham, "The Reconstruction of Pershore Lock," G. Botteley, 6.30 p.m. ★ WESTERN COUNTIES BRANCH: Small Lecture Theatre, University Engineering Laboratories, University Walk, Bristol, 8, "Mechanical and Electrical Problems Associated with Multi-Storey Construction," G. K. Medlock, and Films, "The Pirelli Building in Milan," 6.45 p.m.

Wed., April 12.—11, Upper Belgrave Street, London, S.W.1, "Structural Engineering in Nigeria," A. Brimer, 6 p.m.

Thurs., April 13.—LANCASHIRE AND CHESHIRE BRANCH: College of Science and Technology, Manchester, "Power Stations as a Structural Problem," H. Dickson, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, April 7.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films, 7 p.m.

Mon., April 10.—SHEFFIELD AND DISTRICT SECTION: Livery Clegg House, 44, Union Street, Sheffield, 1, "Cars I Have Owned," T. F. Bailey, 7.30 p.m.

LONDON ASSOCIATION OF ENGINEERS

To-day, April 7.—Carrington Room, Whitehall Court, Horse Guards Avenue, Westminster, London, S.W.1, General Meeting, 7.15 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, April 7.—Mining Institute, Newcastle upon Tyne, "Oil Firing with particular reference to Marine Application," G. R. Gray, 6.15 p.m.

PIPELINE INDUSTRIES GUILD

Tues., April 11.—Tudor Room, Caxton Hall, London, S.W.1, One-Day Symposium on "Economics of Pipelines," 9.30 a.m. and Annual General Meeting, 6.30 p.m.

REFRIGERATION AND AIR CONDITIONING EXHIBITION

Tues. to Fri., April 11 to 14.—Earls Court, London, S.W.5, Second International Exhibition and Convention.

RE!NFORCED CONCRETE ASSOCIATION

Tues., April 18.—MIDLAND COUNTIES BRANCH: Birmingham and Midland Institute, Paradise Street, Birmingham, "The Structural Aspects of Coventry Cathedral," P. Ahm, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Mon., April 10.—HISTORICAL GROUP: Lecture Theatre, 4, Hamilton Place, London, W.1, Discussion on "A Quiz on Little Known Early Aircraft," 7 p.m.

Tues., April 11.—Lecture Theatre, 4, Hamilton Place, London, W.1, "Direct Electrical Power Generation by Thermal and Chemical Means," M. W. Thring, 7 p.m.

Wed., April 12.—GRADUATES' AND STUDENTS' SECTION: Lecture Theatre, 4, Hamilton Place, London, W.1, "Man Powered Flight—Progress to Date," B. S. Shenstone, 7.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., April 10.—ORDINARY GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "Recent Rating Decisions," D. Widdicombe, 5.45 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Mon. to Sat., April 10 to 15.—CORROSION GROUP: Imperial College, South Kensington, London, S.W.7, First International Congress on "Metallic Corrosion."

SOCIETY OF ENGINEERS

Mon., April 10.—Geological Society, Burlington House, London, W.1, "The Use of Electric Light and Heat in Horticulture," A. E. Canham, 5 p.m.

SOCIETY OF ENVIRONMENTAL ENGINEERS

Wed., April 12.—Imperial College, Exhibition Road, London, S.W.7, "Climatic and High Vacuum Environmental Test Chambers," V. A. Austin and Mr. Adamsen, 6 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

To-day, April 7.—Northampton College of Advanced Technology, St. John Street, London, E.C.1, Meeting and Exhibition, "Aids to Training and Education in Automatic Control," 10.30 a.m.

Wed., April 19.—DATA PROCESSING SECTION: Manson House, 26, Portland Place, London, W.1, Annual General Meeting, and "Electronic Telephone Exchanges," T. H. Flowers, 6.15 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., April 12.—LONDON BRANCH: "Hope House," 45, Great Peter Street, Westminster, London, S.W.1, "Road Research," Miss Sabey, 7 p.m.

Advanced Engineering Courses

Nuclear Power Plant Design. NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, St. John Street, London, E.C.1. A short course intended to give a general survey of those sciences and technologies which are necessary in the design of nuclear power plant and to review the special problems associated with this design. The emphasis will generally be upon the nuclear powered electric generating station but mention is made of marine applications. The course runs from Monday to Friday, May 1 to 12. Fee twenty guineas.

Costing for Planning and Control. THE UNIVERSITY OF BIRMINGHAM, Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. A new course, to be held from Monday to Friday, May 8 to 19, presenting a background of cost accounting methods and procedures, and considering in some detail forms of cost analysis appropriate to some of the most frequently encountered problems of management. The course is intended particularly for engineers, operational research workers, production planners, industrial statisticians and managers. Fee sixty guineas.